QATAR UNIVERSITY

COLLEGE OF ENGINEERING

ADMINISTRATIVE CONTROLS FOR MANAGEMENT OF HEAT STRESS IN QATARI CONSTRUCTION SITES

BY

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ABSTRACT

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Title: Administrative Controls for Management of Heat Stress in Qatari Construction Sites

Supervisor ofThesis: Dr. Mohsin, K., Siddiqui .

The State of Qatar is witnessing a significant growth period for all aspects of the community, including the development of the urban and construction sector. The construction sector is a huge sector with lots of investment that are necessary to meet the people needs. Construction sector is facing different challenges such as working under the nature of the climatic conditions in Qatar. Heat and Humidity affect the work activity, health and safety. This research will identify administrative controls that are used in Qatar in order to effectively manage adverse side effect of heat exposure. A questionnaire survey was conducted and the data was collected from the construction sector in the State of Qatar. A total of 157 participants participated distributed among managers, engineers, foremem and HSE staff. Statistical analysis tests were used to evaluate the impact of administrative controls for management of heat stress in the construction sector in Qatar. This research can be useful in establishing a framework for occupational health and safety for the workers working under heat stress. This research would help revisit existing regulations and refine them further in order to manage heat-related illnesses in Qatar effectively. This is in line with the Qatar national vision 2030, which has components of occupational health and safety. This research contributes to

the Qatar national vision with an aim to provide a safe and productive environment for all workers. The result of the study show that most people with different administrative jobs have the knowledge about the risk of heat stress and agree that it is necessary to control heat stress using administrative controls. However, the results show some disagreements between site's office personnel regarding actual controls to be used.

DEDICATION

I would like to dedicate this thesis to my lovely family my mother, father, brothers, and sisters for their continued support and patience with me during my graduate studies.

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I send my highest gratitude to everyone who supported me and stood with me at every moment of my writing for this thesis. I would like to thank Dr. Mohsin K. Siddiqui for his patience, guidance and all kind of support throughout the thesis period. I am very grateful to the College of Engineering at Qatar University for giving me the opportunity to complete my undergraduate and graduate studies. Finally, I would like to thank the Department of Civil Engineering for giving me the opportunity to work as Graduate Assistant during the past two years and to provide me all kind of support.

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ABBREVIATIONS

GSDP	Qatar General Secretariat for Development Planning
HMC	Hamad Medical Corporation
HSE staff	health, safety and environmental staff
IFP	International Fairs & Promotions
MDPS	Ministry of Development Planning and statistics
MLSA	Ministry of Labor and Social Affairs
MOPH	The Ministry of Public Health in the State of Qatar
OTM	OSHA Technical Manual
PeSI	perceptual strain index
PhSI	physiological strain index
PPE	personal proactive equipment
TWL	Thermal Work Limit
WBGT	Wet Bulb Globe Temperature
WS	Weather Spark

Chapter1 INTRODUCTION

1.1 Background about Qatar Vision 2030

The document of Qatar Vision 2030 that is published by the Qatar General Secretariat for Development Planning stated the whole details of Qatar Vision 2030 (GSDP (2008)). His Highness the Father Emir Sheikh Hamad bin Khalifa Al Tani described the Qatar Vision 2030 as *"Comprehensive development is our main goal in striving for the progress and prosperity of our people."* Qatar Vision 2030 is a responsible national vision that aims to achieve a bright future for the State of Qatar (GSDP). It seeks to make the State of Qatar, a productive country with stability in all aspects of the life. The vision also seeks to bridge the present toward the future.

Qatar Vision 2030 depicts a developed vision of building a fair balance in the economy, local society, politics, and investment sector, and create a balanced environment with the human (GSDP). The Vision seeks to develop the population of Qatar so that they can build a prosperous society, develop an equitable and secure society based on good morals and social welfare and be able to interact and communicate with other communities, grow a diverse and ambitious national economy that is capable of meeting the needs of all Qataris in the present and future, and securing a high pattern of living, and manage the environment in a manner that ensures consistency and harmony between economic and social development and environmental stability(GSDP). Also, it depends on the essential factor that mobilizes the energy of all members of the community and to get the benefit from each

individual member in all areas through matching of his capability (GSDP). Because of Qatar Vision 2030, a lot of constructions activities are being performed; some completed, in progress, or under planning stages. Construction sector has become a major component for the country's development.

1.2 Construction Sector in Qatar

Qatar is witnessing a revival of the construction sector in these days and considered the fastest growing market in the region of GCC. In the research done by (International Fairs & Promotions (IFP) Qatar (2017)), the construction sector counts for 47% of the total economic activities in Qatar with a total expenditure of USD 26 Billion for the major projects in the year 2017. It was mentioned by this research that *"The Qatar National Vision 2030 and the FIFA World Cup 2022 are major growth drivers for Qatar's construction industry"* (IFP Qatar (2017)). Construction sector holds the development of the different sectors such as (building, hospitality, tourism, transportation, and infrastructure) (IFP Qatar (2017)). According to Ministry of Development Planning and statistics (MDPS) (June 2017), the type of building permits issued consists of constructing residential buildings such as villas, dwellings of housing loans and apartment's buildings, and non-residential buildings such as public buildings, commercial buildings, workshops/factories, and Mosques. According to MDPS, the total building permits by June 2017 were 629 permits distributed by residential buildings with 312 permits (49%), non-residential buildings with 60 permits (9.5%), additions with 240 permits (38%) and fencing with 17 permits (3%). Also, as known, Qatar will host the world cup 2022 event that requires constructing of major facilities and projects such as new stadiums that meet FIFA

standard requirements; Al-Bayt Stadium, Khalifa International stadium, Lusail Iconic Stadium, Sports City Stadium, Umm Salal Stadium, Qatar University Stadium, etc, Doha metro system to connect the facilities & manage the local transportation in the rush time, the new Hamad international airport, and the new Hamad port. In order to accomplish the construction sector successfully, all difficulties and challenges that are faced during excution phase, including the problems of heat stress, should be controlled effectively.

1.3 Introduction to Heat Stress

According to Weather spark website (WS), the weather of Qatar was defined as *"the summers are long, sweltering, muggy, arid, and partly cloudy and the winters are comfortable, dry, windy, and mostly clear*." The climate has temperatures typically ranging from 14°C to 42°C (SW). Figure 1-1 shows the climate summary for the State of Qatar, where it is shown that the hottest period of the year appears from April till October, and there is a period called sweltering (extremely hot) that is located between May till September. Also, the figure shows that the maximum humidity value can reach around 88% at the end of August.

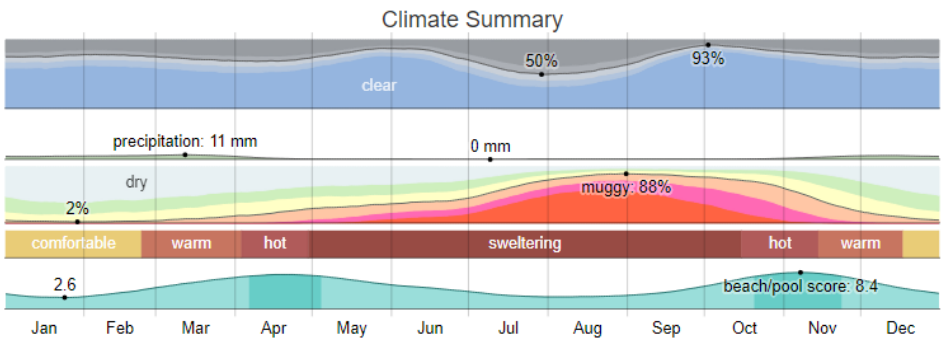

Figure 1-1: Climate summary for the State of Qatar

Figure 1-2 shows the average hourly temperature for the State of Qatar. According to the figure, it is clear that the temperatures from June to September are witnessing a remarkable rise during the whole daily hours. For the period from 10am to 4pm of these months, the average temperature level is described as "*sweltering*" to express the extreme average hot level at these hourly periods of these months, but for other hourly periods, the average temperature period is described as *"hot"* which is hot period but with less effect than the sweltering period. While the months April, May, and October are witnessing a remarkable rise in temperature from 10 am to 4 pm which is described as *"hot",* and for the other hourly periods are described as *"warm"* to express that these periods are not critically hot exposure. For the other remaining months, the average hourly temperatures are varied among cool, comfortable and warm.

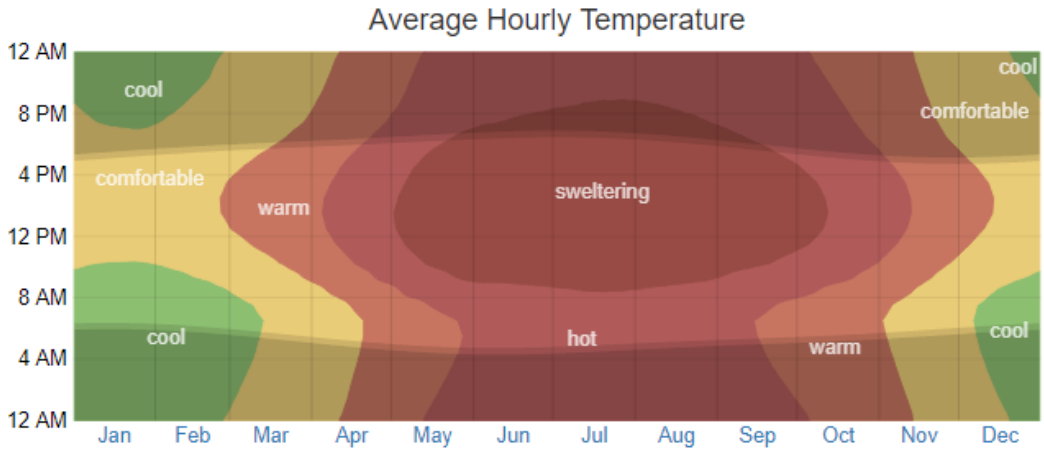

Figure 1-2: Average Hourly Temperature for the State of Qatar

The Ministry of Public Health in the State of Qatar - MOPH's Heat Stress Booklet (2017) describes the situation of heat stress illnesses as in the following series situation. The core temperature of the human body usually appears between the range 36°C to 38°C and the function of the body is cooling the body and keeps the core body temperature between 36°C to 38°C (MOPH's Heat Stress Booklet(2017)). This function is performed by using three cool techniques; by the heart rate to flow and move the heat and blood from heart, lungs and other essential body parts to the skin, and by sweating to play a vital role in cooling function of the blood and body, then by evaporation of the sweat to release the unwanted heat outside the body (MOPH, 2017). The normal core body temperature can be kept in the range between 36°C to 38°C when the cooling function is working well (MOPH, 2017). However, in the case of severe sweating and losing the fluid inside the body under the conditions of significant working rate or working at high heat index, the core body temperature starts to increase above the 38°C limit (MOPH, 2017). The result of the body temperature increment is losing the body's fluid and increasing the body core temperature; this is called the dehydration process where serious of heat stress illnesses will appear for construction workers (MOPH, 2017).

MOPH's Heat Stress Booklet stated the occurrence of heat stress as *"Workplaces involving heavy physical work in hot, humid environments can put considerable heat stress on workers. Hot and humid conditions can occur either indoors or outdoors."* Exposure to heat is a serious issue in Qatar due to the high demand request of workforce to perform the required scope of the construction projects. Working in the construction sector exposes laborers to extreme heat level during work at outdoor work zones, near to hot machinery (generator, equipment vehicles, welding machine,

etc.) or in confined zones. Working in this kind of climate can put the workers in risky situations leading to heat stress illnesses and death. Heat stress can result in *"heat stroke, heat exhaustion, heat cramps, or heat rashes"* (MOPH, 2017). The negative impact on workers is not limited to the mentioned heat stress effects, but the negative side of heat stress can increase the injuries on workers by muscle cramp, dizziness, thirst, vomiting, severe sweating, and syncope (MOPH, 2017).

The disorders of heat stress range from low to sever effect that causes the fatality. Therefore, these diseases are Heat rashes, Heat cramps, Heat exhaustion, and Heatstroke.

MOPH's Heat Stress Booklet (2017) defines the Heat rashes as *"Heat rash is known as prickly heat and is the most common problem in hot work environments."* The major symptoms of Heat rashes are the appearance of red spots, the feeling of severe itching around these places, and the feeling of tingling in the skin and the occurrence of swelling in these areas (MOPH, 2017).

According to MOPH's Heat Stress Booklet (2017), heat cramps is muscle spasms and make them unable to function in the back, arms, and legs because of a severe shortage of the amount of salt inside the body due to the process of excessive sweating. The major symptoms of heat cramps are feeling of pain in the muscles in arms, legs and back, where the pain occurs suddenly at work time or afterward at home(MOPH, 2017).

Heat exhaustion is defined by (MOPH), as the inability of the body to flow the blood to all parts of the body to reduce the level of the body temperature. The symptoms of this disorder are feeling of *"Weakness, Difficulty continuing work, Headache, Breathlessness, Nausea or vomiting, Feeling faint or*

fainting" (MOPH,2017).

MOPH's Heat Stress Booklet (2017) defines the Heatstroke *"Heat stroke occurs when the body can no longer cool itself, and body temperature rises to critical levels."* The major symptoms of this disorder are feeling of *"Confusion, Irrational behavior, Loss of consciousness, Convulsions, Lack of sweating, Hot, dry skin, high body temperature for example 41°C"* (MOPH, 2017).

MOPH is assessing the heat stress based on the following three factors. These factors are *"Personal factors, Environmental factors, and Job factors."*

Personal factors are not measurable factors, so it is hard to suspect the people who will be affected by heat stress. However, some physical situations can be as indications of the ability to sustain high-temperature levels. These personal factors can be identified in the following:

- Weight: overweight body is ineffective with the losing heat function.
- Poor physical conditions: poor fitness body is unable to manage the excessive exposure to heat.
- Previous heat illnesses are an indication that the causality is high exposure to heat illnesses in the future.
- Age indicates the ability of sweating function. Therefore, the function of sweating will not be effective, when body ages and exposes to heat.
- Heart problems cause problems of irregular blood flow to the body organs, which is closely linked to heat illnesses.
- Consumption of alcoholic beverages during the previous 24 hours is hazardous to the worker concerning water shortage in the body.

- Medication cases for a worker, who takes some drugs that may have side effects such as dehydration or excess urination, will increase the risks of heat illnesses.
- The worker who did not spend enough periods to acclimatize is exposed to have heat illnesses.

Environmental factors affect the ability of construction workers to absorb and exchange heat. These factors are *"Radiant temperature, Humidity and air movement."* Radiant heat is the way of transferring the temperature from the hot objects such as the sun, or hot equipment to the worker body, and working in heat conditions such as outdoor work or around hot sources increases the risk of the heat stress. Humidity is the rate of moisture containment in the air; this factor prevents the sweating process to lower the rate of evaporation and thus adversely affects decreasing the body temperature. The air movement helps exchange heat between the body of the worker and the environment. The higher of the air flow, the higher the rate of evaporation of sweating and thus increases the rate of heat exchange between the skin and the surrounding air.

Job factors impose special conditions on workers in order to complete work or to increase safety procedures in which make elevated heat loads on the worker's body. These factors are wearing the clothes and personal proactive equipment (PPE) and workload rate. Wearing PPE such as helmet, safety goggle, safety vest, or safety shoes cause heat stress for laborers. PPE reduce the rate of evaporation in the worker body, which decreases the cooling rate of the body. The workload produces more heat inside the labor's body as long as high workload is required to perform the work performed at the construction site.

To summarize, the weather in Qatar is extremely hot and humid in the summer season, and this will expose the workers to serious issues due to exposure to extreme heat level, and working in this kind of climate can put the workers in a risky situation leading to heat stress illnesses and death. Heat stress is a medical issue that occurs for the people who are working indoor or outdoor and result in increasing the core body temperature, especially at the construction sites. The disorders of heat stress are heat rashes, heat cramps, heat exhaustion, and heatstroke. Assessment of heat stress is based on personal factors, environmental factors, and Job factors. Therefore, active administrative controls should be applied for managing the heat stress in the Qatari construction sites.

1.4 Overview about Administrative Controls for Management of Heat Stress in Qatari Construction Sites

As discussed above, Qatar is witnessing a tremendous urban renaissance that has led to increasing workforce from the world countries to work within the scope of the construction projects to complete them successfully. However, the weather in Qatar is very hot that adversely affects the health of workers with the heat stress-related illnesses because most of the projects are an outdoor work status. This increases the obligations to clarify the administrative controls and regulations that protect workers from these diseases and take into account their circumstances at work. These administrative controls are not valid without the cooperation between all the administrative parties in the construction projects; Managers, Engineers, HSE Staff, Foremen. Therefore, heat stress can be managed and controlled by applying the responsibilities of each individual member of the project staff. According to MOPH,

to control heat stress; an adequate procedure of education, engineering, and work procedures should be followed. Education is to introduce the dangers of heat and the related effects on the workers' health and avoid the causes of heat stress (MOPH, 2017). MOPH describes the engineering controls as the engineering means that can be used to reduce the risks of heat stress. MOPH describes the administrative controls as the work procedures that should be followed to diminish the hazards of working in hot environment.

1.5 Problem Statement

This research is intended to describe the main causes of heat stress in the Qatari construction projects and to outline some of the common management measures that will help to prevent heat stress. Also, the research will discuss some of the main principles involved in heat stress and advices on managing and preventing heat stress in the workplace by providing effective administrative controls. The research also serves as a guide to employers in avoiding discomfort from hot environment at work. The main audience of this research who are working in the construction projects; including managers, engineers, supervisors(foremen), laborers, and health, safety and environmental staff(HSE staff)

1.6 Research Question

The study will try to answer the following research question:

- What are the different techniques that are used in Qatari Job sites in order to manage and control heat stress?

1.7 Thesis Objectives

The objectives of this thesis are:

- Identify the best theoretical practices for management of heat stress
- Identify the current heat stress management practices in Qatar

1.8 Thesis Outline

The thesis is organized into **five chapters**, as described below:

Chapter1: Gives the introduction of the thesis by providing glance about the Qatar National Vision 2030 and construction sector in Qatar, then providing an overview about the Qatar' climate and the issues of heat stress and illustrate the concept administrative controls of heat stress in Qatari Construction sector, and gives the problem statement, the research question and the objectives of the thesis.

Chapter2: Gives the detail of literature review of all the documents that have been reviewed regarding the problem statement of the thesis, the papers that have been reviewed covered the cases of GCC Countries, Hong Kong, United States of America and Australia, then providing the summary review of these papers.

Chapter3: This chapter presents the methodology of the study including research methodology, research size population, research ethics and approval, description of the questionnaire design, data measurement, and description of used Statistics tests and, content test validity.

Chapter4: The aim of this chapter is to analyze the collected data through the questionnaire in order to provide a real picture about the current heat stress management practices in the construction sector in Qatar.

Chapter5: Present the result and the findings of the literature review, and questionnaire and conclude the overall work of the thesis with the recommendations.

Chapter2 LITERATURE REVIEW

In this chapter, the researcher has reviewed different literary sources to dwell deeper into the heat stress issues at the construction sites and the various administrative controls that are adopted by the countries which are presented in the different climatic zones. For this purpose, the researcher has reviewed several of the past research studies and have presented their findings aiming to address the main objectives of the research study which have been identified at the beginning of the research work. The findings of this chapter will help in conducting further research for this research study and reach a definite conclusion.

OSHA Technical Manual (OTM), (2017) defines heat stress as *"The net heat load to which a worker is exposed. Physical exertion, environmental factors, and clothing worn all contribute to heat stress".* The elevated body temperatures could lead to the several of the following illnesses like that of heat stroke, heat exhaustion, heat cramps, heat syncope, heat rash, and Rhabdomyolysis.

According to (OTM, (2017)), the fatalities related to heat have shown that the workplaces which have the temperature of more than 70 degrees Fahrenheit (more than 20°C) could have the heat hazard present when the work activity is taking place either at the same or above the moderate workload. One of the critical factors which are essential for implementing the heat stress-related illness prevention program at the worksite is to make assessments of the work exposure of the conditions which could lead to the heat hazard at the workplace (OTM, 2017). The heat-related illness

prevention program describes the guidelines for the work supervisor to determine the cases of heat stress during work time to control heat hazards. Further the manual points out that though in the case of the indoor and outdoor construction activities the occurrence of the heat hazard is a common phenomenon the heat stress-related illness and fatalities are preventable. The manual also describes that the illness is caused due to heat stress as the core body temperature of the worker rises significantly above the healthy levels. With the rise in the core body temperature, the body is not able to perform the regular activities. Further when the core temperature of the body remains higher for a significant time, then the body releases certain inflammatory agents which results in the damage of the liver and muscle tissues. Due to the prolonged time of body core temperature being above the healthy levels, the processes of body releasing inflammatory agents becomes self-sustaining and leads to the development of the runaway inflammatory response which is known as the *"systematic inflammatory response"* syndrome which generally leads to the death of the person suffering from heat stress(OTM, 2017).

It has been found by WCB, (2008) that the different factors which contribute to the risk of the heat stress comprise of the environmental factors, individual worker factors and the type of construction work that is being done. The different environmental factors which contribute to the heat stress are; air temperature, humidity levels, the flow of air or ventilation, radiant heat coming from the sun or the different types of equipment like that of ovens and boilers, etc.(WCB, 2008). The individual worker factors which lead to heat stress are; hydration, type of clothing, medical condition or any medication, acclimatizing and the fitness levels. Further, the work-related factors which cause the heat stress are; how heavy the work is and how fast and for how

much duration it has to be done (WCB, 2008).

There are different plans that are employed for controlling the heat stress at the construction site and other workplaces. These plans are broadly categorized as the engineering controls and the administrative controls (WCB, 2008). The engineering controls are generally the first actions that are taken. The different actions that are undertaken in the engineering control are as follows:

- In order to reduce the radiant heat, the hot surfaces are either insulated or shielded with appropriate materials.
- For removing the hot air from the workplace and for the reduction of the humidity levels at the workplace, proper arrangements are done for air conditioning and ventilation of the workplace.
- Also, measures are undertaken to either reduce the heavy workload on workers or getting it done at a time or place where there is no heat hazard (WCB, 2008).

For controlling the heat stress, there are also several administrative controls that are undertaken at the construction sites and other workplaces. The fundamental aspect of developing the administrative controls are to make a prior assessment of the type of work that is needed to be done and identifying when and where the heat stress might occur(WCB, 2008). The administrative controls that could be undertaken at the construction sites are illustrated as follows:

- The workers working in the hot regions should be first acclimatized to the heat levels at the worksite. This is due to the reason that the acclimatized workers will sweat more and will eliminate less salt in their sweat which will help them to withstand the higher temperature levels at the work site. This a

gradual process whereby the workers are exposed to the higher levels of heat. It is important to take into consideration that the construction workers should also be acclimatized again when there is leave for more than three days (WCB, 2008).

- Another important administrative control measure is the supervision of the workers when they are working at the construction site. Under this measure, buddy systems are put in place and the trained workers are present at the site to look for the signs of the heat stress among the workers. Further, it is vital for the site supervisors to develop a check-in procedure for the workers working alone when there is a likelihood of occurrence of heat hazard (WCB, 2008).
- Further at the construction site, there should be plenty of drinking water available for the construction workers and the construction workers should be encouraged to drink more water frequently. During the summer conditions, a glass of water after every twenty minutes is recommended. It is also important to ensure that the workers who are exposed to high-temperature levels should drink water at regular intervals even when they are not feeling thirsty. (WCB, 2008).
- Though salt tablets are supplied to the workers working at the construction sites in summer conditions, they are not recommended as they take more time to get dissolved into the system. The better choices are the salted food items and the drinks which contain electrolytes. It is also important that when the construction workers are working in the high-temperature conditions, they should ensure that they do not take caffeinated beverages and alcoholic drinks

as they lead to dehydration.

- Further, it is important to ensure that such work where the workers are exposed to higher temperature levels should work in the recommended work rest cycles which are developed for the different conditions and the type of heat exposure.
- During the hot seasons, the project managers and the site supervisors should ensure that the work/rest schedules are planned according to the broadcasted humid index or the temperature levels. It is recommended that the heavy or outdoor construction work is scheduled for either early in the morning or late in the night (WCB, 2008).
- The project managers and the site supervisors should ensure that all the workers have the personal protective equipment when they are exposed high temperature. Further when a particular work is planned than the heat retention during that activity should also be taken into consideration (WCB, 2008).

Since the scope of this research study is mainly related to the administrative controls, hence the researcher has not considered the engineering controls, but it is important to consider the connections between engineering and administrative controls. The literature review part is searched mainly related to administrative controls for heat stress issues at the construction sites.

2.1 The Case of GCC Countries

Since the Gulf countries face long heat seasons and many construction activities have taken place in the region thus there are a lot of research studies that have been conducted related to the heat stress and their prevention in the region. One of such research studies which were conducted McDonald et al. (2008), whereby the researcher has described regarding the different heat stress related prevention measures that have been undertaken in Qatar construction industry. According to McDonald et al. (2008), the researchers said that *"Environmental and working conditions in the Arabian Gulf make heat stress prevention a safety and health priority."* The researcher found that after successfully applying the measures that were associated with controlling the heat stress; it was found that there was significant reduction in the number of heat stress related incidents from 0.164 for every 200,000 workers to just 0.012 for every 200,000 in a time duration of three years(2003-2006) (McDonald et al., 2008). The researcher pointed out that this was possible to achieve by the application of the engineering controls for the reduction of the heat and the implementation of the different administrative controls in the various locations of the work site. The different administrative measures that are undertaken at the workplace comprise of the using umbrellas at the workplace, providing the insulated water bottles, using the evaporative bandanas, acclimatization of the workers, rotation of the employees, using a buddy system, following the recommended work-rest period and the following the appropriate guidelines for the consumption of water(McDonald et al., 2008). The evaporative bandanas are generally lined with super evaporative PVA materials for soaking up the moisture and providing instant cooling relief. These are worn around the neck and help in keeping the workers cool, fight fatigue and enhance

productivity.

Another research study conducted by Miller et al., (2011), the researchers conducted tests for the evaluation of the self-pacing as an administrative control mechanism for protection against the effects of heat stress for the UAE construction workers. For the purpose of this research study, the researcher collected the data from the several construction sites that are present in the United Arab Emirates (Miller et al., 2011). According to the findings of the researchers the Arabian Gulf region faces severe thermal conditions in the summer months and most of the countries in the Gulf region have witnessed a boom in the construction industry, and a large number of workers are working in the construction industry in these nations. The researcher points out that though the government of UAE has made it mandatory to provide compulsory water break between 12.30pm to 3 pm in the afternoon for addressing the issue of rising cases of heat stress-related illness among the construction workers. But it does not have much impact on the heat stress-related illness due to the fact that the thermal stresses are much higher in the mornings and the late afternoons due to the fact that during that the relative humidity is very high around more than 80% and there is also lack of air movements(Miller et al., 2011).Thus the researcher points out that the most flexible heat management system would be utilizing the Thermal Work Limit (TWL) for the assessment of the thermal stresses so that the managers of the construction site can identify the unsafe thermal conditions at the worksite and thus accordingly they are able to focus on the protective measures and behaviors which lead to laying more emphasis on hydration in regular intervals of time and self-pacing of the work. For this purpose, the researchers measured the heart rate and the aural temperature in 150 respondents for 12 hour time period. This process was continued

for two days' time period. The environmental parameters were measured for the purpose of the quantification of the heat stress by the thermal work limit. The findings of the research study showed that there is no impact of the variations that take place in the environmental thermal stresses on the average working heart rate or the aural temperature (Miller et al., 2011). Thus the research study found that the self-pacing is highly significant as a protective measure in the hot working conditions in the construction industries in the Gulf nations. The main advantage of this approach is that the implementation of this approach does not require a highly informed or trained workforce and thus this approach should be part of a holistic approach to the management of the heat stress (Miller et al., 2011).

A research study conducted by Bates and Schneider, (2008) reviewed the hydration status and the physiological workloads of the UAE construction workers. The primary purpose of the researchers to conduct the research study was to evaluate the physiological responses of the construction workers who are working in the thermally stressful conditions in UAE. For this purpose, the researcher has employed the Thermal Work Limit (TWL) as a tool for assessment of the environmental risk (Bates and Schneider, 2008). For the purpose of this research study, the researchers took the measurements of the oral temperature, fluid intake and urine specific gravity which was collected and the continuous heart rate was also monitored for making the assessments of fatigue among the workers. All the subjects were monitored for duration of three consecutive shifts. For the purpose of making assessments of the thermal stresses, the researcher used TWL and Wet Bulb Globe Temperature (WBGT). The findings of the research study show that most of the construction workers started working in dehydrated condition and they were able to maintain this

level for 12 hour time period. The average intake of the fluid of the workers was around 5.5 liters. The researchers did not find any significant changes in the core temperature of the body and the average rate of the heart between day 1 and day 3 and also did not found any significant changes at the start and the finish of the work despite the high variation in the thermal stresses. The findings of the research study also showed that the workers working on the construction sites in UAE were also not physiologically challenged despite the harsh environmental condition that was witnessed by them. There was sufficient thermoregulation which showed by the fact that the core temperature of the body was not elevated significantly (Bates and Schneider, 2008). The findings of the research study showed that it is possible for the construction workers to work in the hot weather conditions without of the adverse physiological effects if they are provided with the appropriate fluids for the hot conditions and also if they are allowed to self-pace their work. The findings of the research study also showed that the workers will self-pace their work according to the prevailing weather conditions. It was also indicated, that the application of the WBGT as a thermal index in the case of the Gulf countries is not that much effective for practical use but thermal work limit (TWL) was found to be a precious tool in the assessment of the thermal stresses

In the research study conducted by Joubert, Thomsen, and Harrison, (2011), the researcher determined the impact of the safety and heat program developed by the researcher for the construction workers working in the different construction sites in UAE. The safety and health program that was developed by the researcher was developed keeping in mind the ambient air temperatures in the Middle Eastern countries including Gulf region often reached to the level of 45°C and the levels of

humidity in these regions reach to the levels of higher than 90%. The program that was developed by the researcher was part of the administrative controls that could be implemented at the workplace. This program was comprehensive, multimedia-based, economic educational and awareness program. The feedbacks that were received regarding the programs from the workers working in the different construction sites showed that there was a high degree of support and satisfaction among the participants of the program. The findings of the research study showed that there was *"a marked reduction in heat-related illness over a period of 2 years (2008–2009) at 2 companies, one of which reported a combined 79.5% decrease in cases (15.3 vs 1.16 cases per 1000 workers) while the other experienced a 50% reduction in serious cases (0.08–0.04 cases per 100 000 work hours)" Joubert, Thomsen, and Harrison, (2011).* The findings of this research study show that the education and awareness of the workers could be employed as administrative controls for prevention of heat stresses among the workers (Joubert, Thomsen, and Harrison, (2011).

2.2 The Case of Hong Kong

One of the essential studies conducted regarding the effectiveness of the administrative controls to counter the heat stress in the construction industry in Hong Kong has been done by Yiu, (2012). According to the researcher, the construction workers in Hong Kong are more susceptible to the heat stress due to the hot and humid weather in Hong Kong. The researcher found that though the workers who are working outside especially during the hot seasons are at higher risk of facing the heat stroke, there is lack of strategies to effectively reduce the impact of the heat. The aim of this study is to recognize the existing measures of heat stroke in Hong Kong for the

construction sites and assess the influent of these measures in order to control heat stroke. The researcher points out that it is the responsibility of the site management supervisors to remove the workers from getting exposed to the hazards of heat stroke. For this purpose, the researcher conducted a survey questionnaire research among the site management staff and the front-line workers so that it is possible to assess the level of knowledge and get a better understanding of the different strategies that are adopted by them to prevent them from heat stroke (Yiu, 2012). The researcher collected the data from six selected construction sites. The researcher found that most of the respondents have good knowledge of the heat stroke and thinks that the current levels of heat stress at the construction sites are very uncomfortable. In the research study, the researcher identified existing eleven heat stress control measures and then accordingly reviewed their effectiveness on the basis of the hands-on experience that the researcher received from the respondents. From the survey, the researcher found that though most of the respondents were satisfied with the current practices that were taken to manage the heat stress; they believe that there is still a large scale for improvements. In order to make these improvements, (Yiu, 2012) recommended that *" it is recommended that the Hong Kong Observatory should develop a heat stress index which will be announced as part of the weather forecast during the summer seasons. Furthermore, proper heat stress guidance notes should be compiled by the government for implementation of an effective heat stress management system in the construction industry of Hong Kong."* (Yiu, 2012).

In another research study conducted by Rowlinson et al., (2014), it was found that the heat stress results in the accidents on the construction sites in Hong Kong due to the range of different factors. These factors included, illness caused due to heat

exposure, muscle fatigue which reduces or impairs the capability to move the limbs and reduces the physical and mental ability. The researchers pointed out that there are generally six important factors which determine the heat stress; air temperature, levels of humidity in the air, the radiant heat level, the speed of the wind which shows the environment, the metabolic heat which is generated from the different kinds of physical activities and the effect that the clothing has on the workers as the clothing moderates the exchange of heat between the body and the outside environment(Rowlinson et al., 2014).The researcher found that it is important to have a regionally based heat stress management system and practices which should be according to the unique climatic conditions that are present at the particular location, the construction working practices and the propensity for acclimatization by the local workers in the different geographical regions. The researcher also found that the some of the most effective administrative controls that are followed in the different regions in the Hong Kong are; controlling the exposure to heat stress by the application of the action triggered threshold system, monitoring and controlling the continuous work time along with the mandatory work-rest time schedules and also empowering the workers for working at self-pace (Rowlinson et al., 2014). The action triggered threshold system is a defined as a series of simplified action-triggered decision making tools which would work and could be easily adopted with the complete construction safety management plan (Rowlinson et al., 2014). It is important to ensure that the tools are usable and should be based on the regional research so that they are relevant, appropriate and effective simultaneously maintaining the legitimacy and not interfering with the local cultural norms and the values (Rowlinson et al., 2014).

In another research work conducted by (YANG and CHAN, 2017), the authors have determined the heat stress interventions that are in practice for Hong Kong and have found the gaps that exist in the suggested interventions recommendations to improve the effectiveness of the heat stress interventions. The research classified the selected past studies into three categories; administrative controls, environmental engineering controls and personal engineering controls (YANG and CHAN, 2017). The research found that most of the past research studies which have conducted in tackling the heat stress in Hong Kong have found that the administrative intervention controls are more effective in tackling the heat stresses (YANG and CHAN, 2017). The research study also found that the main administrative controls that are employed to tackle the heat stress in Hong Kong are rescheduling of the work, adequate provision of the drinking water and the monitoring of the human heat strain. Further other effective administrative controls that were employed in the Hong Kong industry were optimal work pattern, having an early-warning system, optimized work-rest regime, establishing a heat stroke prevention system and providing optimal time for recovering (YANG and CHAN, 2017).

In the research work conducted by Chan, Yam, Chung and Yi, (2012), the main purpose of this research is to develop a model of measuring the heat stress parameters based on the index of wet bulb globe temperature (WBGT) index. For the purpose of this research study, the researchers took the measurements of physiological, work–related, environmental and personal parameters from four different construction sites which targeting the construction workers (Chan et al., 2012). The research found that in order to determine the construction workers' physiological responses working in Hong Kong construction region; drinking habit, age and work duration are the major

critical predictors for this purpose. The research also found that the other general predictors are percentage of body fat, resting heart rate, air pollution index, WBGT, smoking habit, energy consumption, and respiratory exchange rate(Chan et al., 2012).

In the research work conducted by Hui and Wong, (2011), the researcher mentioned that *"In Hong Kong, large number of workers in construction sites have to work long hours in thermally stressful environments, and with heavy physical workload. They are at high risk and this may pose special hazards of heat stress".* The aim of the research is to find the hazards of heat stress at the construction sites, especially in Hong Kong, and find out the most effective control methods (Hui and Wong, 2011). The research found that the administrative and the engineering methods are the most effective methods to tackle the heat stress in the climatic conditions of Hong Kong faced by the construction workers in the country (Hui and Wong, 2011). The research found that the Wet Bulb Globe Temperature (WBGT) is the most optimum heat stress indices for the weather conditions in Hong Kong (Hui and Wong, 2011). Further, the researcher also points out that adequate health and training project should be implemented for the workers at the construction site so that it is possible that the workers working at the construction site have the necessary education so that they are able to improve their knowledge (Hui and Wong, 2011).

In the research work conducted by Chan, Yi, M. Chan, Wong, (2012), the main purpose of this research is to develop the thermal work limit (TWL) index based on an enhanced model using multi-dimensional indicators. The data collected for this purpose were based on field studies measurements between July and September 2010 in Hong Kong for ten rebar construction workers whom are experienced and healthy workers (Chan, Yi, M. Chan, Wong, 2012). For the purpose of this research study, the

researchers took the measurements of physiological, work–related, environmental and personal parameters from four different construction sites in order to develop the heat stress model. The research found that TWL is accepted statistically, and most essential predictors for the purpose of determining the workers' physiological responses are Alcohol drinking habit, age and work duration (Chan, Yi, M. Chan, Wong, 2012). The heat stress model of this research reported that heat stress control guidelines for construction workers can be produced efficiently by providing a scientific prediction of the reality conditions of working in hot weather (Chan, Yi, M. Chan, Wong, 2012).

In the research study conducted by Yang and Chan, (2015) determined that the effectiveness of the perceptual strain index (PeSI) in the heat strain assessment in construction industry, especially in Hong Kong. The researcher found that though the physiological strain index (PhSI) is universally and comprehensively employed in the construction sites for the heat strain measurements. Also, the researcher showed that "*the perceptual strain index (PeSI) combines* both the rating of perceived ex- ertion (RPE) and Thermal sensation (TS)" (Yang and Chan, 2015). PRE is described by the researcher as *"The rating of perceived ex- ertion (RPE) allows individuals to subjectively assess their overall feeling of physical stress, effort, and fatigue in relation to a specific task"* (Yang and Chan, 2015). Also, the researcher described TS as *"Thermal sensation (TS) measures the perception of individuals in a certain thermal condition"* (Yang and Chan, 2015). The main restriction of PeSI method is that this method is invasive on-site measurements and this type of measure requires very accurate measurements (Yang and Chan, 2015). On the other hand, the researcher found that the perceptual strain index (PeSI) is very user-friendly and is

also said to be the practical indicator of the heat strain measurements. It is one of the best administrative controls that can be put in place at the construction sites in Hong Kong for the heat strain assessments. The researcher took the measurements from the ten males and two female construction workers in the hot weather conditions. The researcher collated the physiological parameters (such as that of core body temperatures, heart rate) and the perceptual variables (like that of the thermal sensations, perceived exertion) at the time intervals of 3 minutes. Also, the researcher asked the participants to wear two different work uniforms (uniform A & uniform B) in two official workdays. The researcher described uniform A as *"Uniform A is newly designed with sophisticated consideration of superior heat-moisture performance of fabrics, smart design, and the specific requirement from industry",* and uniform B as *"a commercially available and commonly worn uniform by construction workers".* The researcher conducted the ANOVA analysis using the two variables clothing & time and found that perceptual strain index (PeSI) was helpful in differentiating the heat strain levels among the different uniforms of the construction workers. The researcher also found that not only does the perceptual strain index (PeSI) changes in the similar fashion as that of the physiological strain index (PhSI) but this tool is also a powerful tool to reflect the different level of the physiological strains(Yang and Chan, 2015). Thus it could be said that the PeSI provides a considerable potential for the assessment of the heat strain in the stimulated working conditions.

In another research work conducted by Leung, Chan and Yuen, (2010), the main purpose of this research is to improve the performance of safety of the construction workers in the hazards work places in Hong Kong. For this purpose, the research aims to detect different kind of stressors which affect the job and emotional stress of the

construction workers in Hong Kong, and check for the effects of the both stresses on the construction workers injury incidents (Leung et al., 2010). Eleven stressors were identified by Leung et al., (2010) such that *"work overload, role ambiguity, lack of autonomy, unfair reward and treatment, appropriate safety equipment, optimism, inter-role conflict, poor workgroup relationship, lack of feedback, poor physical environment, and unsafe environment."*. The research found that emotional stress affects the whole identified stressors and the injury incidents of the construction workers (Leung et al., 2010). The research found that the stressors such that *"work overload, inter-role conflict, poor physical environment, unfair reward and treatment, and appropriate safety equipment"* are the main predicted factors in order to predict emotional stress for the construction workers in Hong Kong (Leung et al., 2010). Further, the research found that stressors such that *"poor workgroup relationship, work overload, and inter-role conflict*" are the main predicted factors in order to predict Job stress for the construction workers in Hong Kong (Leung et al., 2010).

2.3 The Case of United States of America (Hot Region)

In the research done by work Varley, (2004), he determined the heat-stress exposures and the different interventions that are undertaken for the mine workers in America. The researcher along with the researchers from the National Institute for Occupational Safety and Health (NIOSH) and the mine operators conducted the study to determine the heat risk exposure to the underground rescue workers of the mines (Varley, 2004). The researchers found that the mine rescue workers have to face extreme heat loads because they have to enter the hot and poorly ventilated environments, especially under those conditions when they have to wear the breathing

apparatus. During such circumstances, there is a burden on the rescue workers of the closed–circuit breathing apparatus (CCBA); they are unable to drink fluid in extended duration of time. Also, they face the high risk of ventilation disruptions along with the risk of fires which increases the chances of heat stress and heat-related illness at the time of responding to emergency situations. In their research work, the researcher estimated the ambient environmental conditions and the heat strain indicators along with the conventional monitoring tools for ventilation at the time of mine rescue exercises that are conducted in the different underground mines in America (Varley, 2004). Further, the researchers also took into observation the team activities to determine the impact that the work rate have on the total heat load. During this time, the researcher tested the effectiveness of the different administrative and the engineering controls which are recommended for workers working in the high-temperature zones. The researcher examined the effectiveness of the administrative controls like that of limiting the duration of activity based on the environment, restricting work rate by recovery heart rate (Varley, 2004). Also, the researcher tested the effectiveness of the different engineering controls like that of using apparatus for cooling down inhaled air and active cooling by supplying water (Varley, 2004). The researcher found that all the above stated administrative and engineering controls are adequate when they are applied as per recommended instructions. The researcher also noted that it is important that the initial resting body temperatures of the mine workers should be determined at first stage of work. The researcher found that those having the high initial resting body temperature might be facing the risk of overexposure. Further, the researcher found that it is crucial that the work rate is controlled as periodic intervals of rest will allow the workers to tolerate the heat during the planned

duration of time. Through the investigation, the researcher also found that a resting heart rate is a useful tool for evaluating whether the team is ready to proceed. According to the findings of the researcher by reducing the rate of rising in resting heart rate, the rate of increasing of core temperature could be controlled (Varley, 2004). The researcher recommends that the resting time should be extended till all the workers have their heart rates not more than 10% of previous check or 100bpm. With regards to the effectiveness of the apparatus for cooling the inhalation air, the researcher found that though the apparatus was not effective in reducing the core body temperature significantly, it does provide comfort to the workers. The researcher evaluated the CCBA masks which have the provision of 2L of drinking water for the rescuers. The researcher found that regular hydration of the workers was effective in reducing the core body temperature and also provided them comfort (Varley, 2004).

In another research study conducted by Tymvios, Behm and Jia, (2016) pointed out that there are no specific regulations for occupation heat exposure and it is up to the employers to provide the workers with a workplace which is free from any kind of hazard which can cause harm to the workers. The researchers summarized the findings from several other research studies. They concluded that the most of the heat stress-related incidents occur in the southern states of United States of America. Also, they found out there are different administrative controls that can be effective in these regions like that of removing the workers from the direct sun to a much calmer place for taking rest, injecting the electrolyte solution in the workers when they are facing symptoms of heat stress-induced illness and having trained medical staff at the workplace for managing the heat stress-related illness emergencies (Tymvios, Behm and Jia, 2016). An electrolyte solution which is also sometimes referred to as the ionic

solution contains essential minerals and water which helps to maintain the electrolyte balance in the body and keep the core temperature of the body regular. Further, the researchers also suggest installation of the appropriate ventilation and heat control systems in place and using the pneumatic tools so that the workers do less physical labor. Further measures that were suggested by the researchers comprise of making provisions for adequate drinking water for the workforce and monitoring that they are drinking water on a regular time period, acclimatizing the workers to heat gradually. Also, the measures suggested using the loose fitted clothes and also training the workers regarding the symptoms and treatments of the heat stress (Tymvios, Behm and Jia, 2016).

2.4 The Case of Australia

In the research study conducted by Xiang et al., (2015), it was found that since Australia has a warmer climate in most of the regions thus the workplace heat exposure to the people working in the different Australian industry activities is very high. The researcher used the quantitative survey method for conducting the research study and found that 90% of the respondents were moderately or more concerned about the extreme heat condition. Further, there were close to 20% of the respondents were not satisfied with the existing heat stress prevention and heat stress management strategies that have been put in the workplace (Xiang et al., 2015). Further the significant barriers that were recognized by the respondents regarding the ineffectiveness of the heat stress management is due to the fact that there is lack of awareness among the workers regarding the effective heat stress management strategies that are associated with the climatic conditions of the region, insufficient

training of the workers, unsatisfactory management commitments and the low compliance with the prevention policies(Xiang et al., 2015). The findings of the study shows that different administrative controls that are put in place for the heat stress management in the workplace in Australia are hydration maintenance, self-pacing of the activities, heat acclimatization, detection of early symptoms of heat illness, personal protective equipment for balancing the body temperature(Xiang et al., 2015). *"When asked which aspects of heat-related training should be strengthened, respondents suggested: "Hydration maintenance, self-pacing, heat acclimatization, and early symptoms of heat illness", "impact of personal protective equipment on human body heat balance maintenance", "individual heat risk factors e.g. predisposing medical conditions, lifestyle, fitness level", "annual training prior to hot seasons*"" (Xiang et al., 2015). Around 82% of the respondents did not have any idea of the heat stress management plan that the organization has in place for the event of tackling the rise in the hot weather conditions. The researcher found that the workers identified that there is a need for more training for the workers regarding the identification and the management of the heat stress symptoms (Xiang et al., 2015).

In another research work conducted by Bahn (2013), the researcher presented the findings of the two workshops that were conducted by the researcher with the 77 workers of the underground mining operations that were undertaken by an organization in Western Australia. The researcher found that heat stress was one of the most important risks that were faced by the underground mine workers and have resulted in the different illness like that of muscle fatigue, dehydration and also in some cases death (Bahn, 2013). The researcher found that the regular hydration of the workers, monitoring of the workers during their activities and looking for heat stress-

related symptoms, following the recommended work-rest schedules and providing specialized suits to the workers to tackle the extremely hot weather environmental conditions are some of the most important measures that are undertaken in the underground mining workplaces in Australia (Bahn, 2013).

2.5 How Ministry of Public Health in the State of Qatar Control Heat Stress?

MOPH, the Ministry was called Supreme Council of Health (SCH) – at that time in Qatar, conducted a workshop on 18 April 2015 to warn against the risks of heat stress and how to deal with it. The workshop title was *"Beware of Heat Stress"* in co-operation with Hamad Medical Corporation (HMC), Ministry of Labor and Social Affairs (MLSA), Qatar Petroleum and SCH. Experts and authorities from Occupational Health Sections and Occupational Health Officials from private companies and organizations attended the workshop which showed lectures on dealing with heat stress and how to avoid it (MOPH, 2015). The workshop illustrates that the heat stress signs spread over the region, and people should be aware of prevention methods. Also, the workshop assured the importance of avoiding heat stress by all employees (MOPH, 2015). All employees should know well how to keep their staff in safe and educate them how to go against heat stress (MOPH, 2015). It was also added that the heat stress has a significant impact on the body and HMC's emergency department should take steps to cut down the number of the injuries (MOPH, 2015). The people who attended the workshop agreed to do their best to reduce heat stress, and they know that there is no way to go away from exposing to heat stress, but many approaches can be taken by persons to avoid heat stress. These techniques are mentioned below: (MOPH, 2015)

- Teaching the ways of preventions for all members who are working in hot environments the ways of preventions.
- Distributing the heat stress prevention plans in all workplaces by different languages.
- Launching campaigns aiming to raise worker's awareness of heat stress.
- Continuous training courses for the workers to define the importance of reducing the heat stress illnesses in the workplace and other places.
- Teaching the dangers of heat stress for all workers using their mother's languages.

MOPH's Heat Stress Booklet (2017) is the heat stress guidelines and recommendations plan that is issued by MOPH. The purpose of this booklet is to provide the definition, disorders, effects and precaution and control approaches. The targeting people in this booklet are *"employers, managers, supervisors, workers, joint health and safety committee members, health and safety representatives, employer associations, and health and safety Professionals."* (MOPH, 2017). The occurrence of heat stress is described by MOPH's booklet when the core body temperature of the body rises above the normal range; the normal range of the core temperature varies between 36 °C to 38 °C (MOPH, 2017). The disorders of heat stress range from the low condition to life-threating condition; so the disorders are *"Heat rashes, Heat cramps, Heat exhaustion, and Heatstroke."* (MOPH, 2017). For controlling the heat stress, several control approaches are mentioned in MOPH' booklet and these controls are illustrated as follows:

- Detection of early symptoms of the disorders of heat stress. Heat rashes symptoms are an appearance of red spots, the feeling of severe itching around

these places, and the feeling of tingling in the skin and the occurrence of swelling in these areas. Heat cramps symptoms are feeling of pain in the muscles in arms, legs and back, where the pain occurs suddenly at work time or afterward at home. Heat exhaustion's symptoms are *"Weakness, Difficulty continuing work, Headache, Breathlessness, Nausea or vomiting, Feeling faint or fainting."* (MOPH, 2017). Heat stroke' symptoms are *"Confusion, Irrational behavior, Loss of consciousness, Convulsions, Lack of sweating, Hot, dry skin, high body temperature for example 41°C"* (MOPH, 2017).

- In case of having the heat stress disorder, MOPH's booklet illustrated guidelines for treatment, and these treatments are illustrated as follows:
  - The treatment for heat rashes is conducted by resting in a cool shaded area and have a cool shower to make the body dry (MOPH, 2017).
  - The treatment for heat cramps is let the body's muscles to relax for enough time so that the energy of the body will get back, and drink enough fluids to replace the losing amount of salt such as *"carbohydrate or electrolyte replacement fluids."* (MOPH, 2017).
  - The treatment of heat exhaustion is to help the laborer who has heat exhaustion to cool down and rest in a cool area, provide losing clothes, and have a shower to cool his body and call the emergency services to make the necessary biometrics to determine the severity of the condition (MOPH, 2017).
  - The treatment of heat stroke is to call emergency services immediately, and provide aggressive body cooling by a cool shower, or spray the water directly to the body, and provide cool sheets and wrap them around the

body (MOPH, 2017).

- Assessment of heat stress severity level considers three main factors which are *"Personal factors, Environmental factors, and Job factors.* Personal factors are weight, poor physical conditions, previous heat illnesses, age, heat-related illnesses, consumption of alcoholic beverages, medication cases for a worker and non-acclimatized worker. Environmental factors are radiant temperature, humidity and air movement. Job factors are wearing the clothes and personal proactive equipment (PPE) and workload rate (MOPH, 2017).
- Measuring the thermal environment through WBGT that is calculated by determining three factors; air temperature, radiant heat and humidity. However, it was mentioned in the booklet that the workplaces might not be practical to use WBGT due to the complicated measuring process that takes into account the temperature, humidity, radiant heat, wind velocity and other factors. Therefore, measuring the thermal environment using WBGT is usually not used in the workplaces. MOPH also mentioned using heat index which is more accessible than WBGT and was described as how hot the body feels and depends on the air temperature and humidity level. MOPH also illustrated that continuous physical activities are hazardous for two groups; when heat index is 45°*C* or more for moderate acclimatized worker or heavy acclimatized work, and when heat index is 49°*C* or more for light acclimatized worker or light workload (MOPH, 2017).
- MOPH recommends all employers to set up a program called *"Medical Monitoring"* for all workers who are working and exposed to heat stress. The purpose of this program is to evaluate and check the workers' health and

physical well-being during the work in hot environments and provide emergency medical care for the workers (MOPH, 2017).

- Another important control approach is the acclimatization which was defined as *"Acclimatization is a gradual physiological adaptation that improves an individual's ability to tolerate heat stress."* MOPH mentioned that the period of acclimatization should take about one week, so the worker will become 90% able to perform the work. Also, the experienced worker should acclimatize faster than a new worker. Also, acclimatization should be considered if the absence was for more than four days which require one-day reduction for the worker performance, and in the case of illness condition; double acclimatization period should be considered (MOPH, 2017).
- Provide frequent work break and Job rotation.
- Provide unlimited potable drinkable water.
- Provide appropriate ventilation for air movement.
- Provide heat stress preventative training.

Summary

The principal purpose of chapter 2 is to review what has been discussed about administrative controls for the heat stress at the construction projects in GCC countries, Hong Kong, United States of America and Australia, in order to find out the best administrative controls for heat stress in the Qatari construction sector. The review of the several literatures regarding the management heat stress issues using the administrative controls showed that the main administrative controls that are employed all the different category of the construction sites that are present in the

various parts of the world, especially for Qatar, are hydration maintenance, self-pacing of the activities, heat acclimatization, detection of early symptoms of heat illness, personal protective equipment. The review of the literature also found that regarding the heat stress indices WBGT and TWL are mostly employed in almost all the nations for the effective and practical measurements of the heat stresses and mentioned clearly in the MOPH's booklet, but WBGT is not that much effective in the climatic conditions of Gulf region. Further, the researcher found that the effectiveness of the administrative controls like that of limiting the duration of activity based on the environment, limiting the work rate by recovery heart rate, using apparatus for cooling down inhaled air and active cooling by supplying water are enhanced when they are applied as per recommended instructions, it should be mentioned that the previous three administrative controls are not involved in the MOPH' booklet, but MOPH illustrated the limitation of the work duration should be based on a clear acclimatization period and workload limit, and the heart rate measurement was mentioned for the medication program that was recommended by MOPH for old people. The findings of the review of the literature also shows that the there are generally six important factors which determine the heat stress; air temperature, levels of humidity in the air, the radiant heat level, the speed of the wind which shows the environment, the metabolic heat which is generated from the different kinds of physical activities and the effect that the clothing has on the workers as the clothing moderates the exchange of heat between the body and the outside environment. The previous six factors are illustrated in MOPH's booklet under three principles factors which are personal factors, environmental factors and Job factors. The review of the literature also pointed out the fact that it is important to

have regional heat stress management strategy which is developed as per the local climatic conditions. Further, the review of the literature found that the perceptual strain index (PeSI) changes similarly as that of the physiological strain index (PhSI) and this tool is also a powerful tool for reflecting the different level of the physiological strains. Thus it could be said that the PeSI provides a considerable potential for the assessment of the heat strain. However, PeSI and PhSI are not mentioned in the MOPH's booklet.

2.6 Research Scope Based on the Literature Findings

This research will focus on the various administrative controls that were found to be essential for Qatari construction sites from the review of the literature, including MOPH' booklet, like that of developing a work schedule which allows heat acclimatization, increasing the frequency and the length of breaks, scheduling of the work during the cooler times of the day and the year, making appropriate arrangements for hydration with unlimited potable drinkable water for the workers, allowing self-pacing of the work to be related to workload rate and condition of the work that is indoor or outdoor, providing adequate training to the workers by providing heat stress preventative training periodically, having sufficient ventilation and air conditioning system in place at the work site, detection of medical issues that could be related to heat stress, control the work cautiously for heat index period above 45 $^{\circ}C$, and control the fluids that are consumed by the workers and the food as well.

Chapter3 METHODOLOGY

3.1 Introduction

The purpose of this chapter is to find out and achieve different approach solutions to the **Research Question: What are the different techniques that are used in Qatari Job sites in order to manage and control heat stress?** This chapter shows the methodology approach of the study including research methodology, research size population, research ethics and approval, description of the questionnaire design, data measurement, and description of used statistics tests and, content test validity.

3.2 Research Methodology

The research methodology used was based on the literature review approach and the data that was collected from the targeted construction sector in the State of Qatar, and then analyzed to evaluate the impact of administrative controls for management of heat stress in the construction sector in Qatar.

Data Collection Methodology

This research aims to examine the role of administrative controls for management of heat stress in the construction sector in Qatar in order to achieve the objectives of the research. Thus, the data to be collected through:

1. Secondary Data

In order to achieve the Objective#1: Identify the best theoretical practices for management of heat stress, the secondary data was used for this purpose and includes

internet, papers, books, journals, and previous thesis related to the research topic.

2. Primary Data

In order to achieve the Objective#2: Identify the current heat stress management practices in Qatar; the primary data was used for this purpose. The primary data is mainly the data the was collected through the research questionnaire, which was explicitly designed for this study due to the type of data needed to examine the hypothesis of these data; the questionnaire seems to be the most proper method to collect data in the current study because the population consists of employees who are working in the construction sector in Qatar.

Research methodology part depends on the analysis of data on the use of detailed descriptive analysis, which depends mainly on the statistical analysis program (SPSS).

3.3 Population and Sample Size

The required population of the study is involved within construction sector in Qatar, and we used the Electronic version questionnaire, and 157 surveys are collected. These participants distributed among managers, engineers, foremen and HSE staff.

3.3.1 Sample Size Calculation

For the purpose of reaching a certain level of population degree through the following steps:

1. Assume that there are two population sizes; one is infinite population size which represents the targeting population in the Qatari construction sector, and the second one is calculated sample size.

2. True estimated value (P) is 70% which represents the estimated prevalence level of the responses.
3. Desired accuracy (e) is $\pm$10% which represents the acceptable level of error.
4. Desired confidence level is 90% and the corresponding value of the desired confidence level (90%) from the standard normal distribution (z) is 1.645.
5. Computing the possible sample population size (n) using the formula: $\frac{z^2 \times P \times (1-P)}{e^2}$, because it is not possible to determine the size of population as assuming before to be infinite population size. Therefore, the sample required size can be calculated using the previous formula with the corresponding numbers in the previous steps, and it was found that the sample size is 57 participants and the numbers of responses that have been collected (157 participants) are greater than the required sample size. Therefore, the objective of the study regarding sample size is valid.

3.4 Research Ethics Approval

This research involves human subject, due distributing the questionnaire form among the population participants and analyzing their opinions. Therefore, a research application along with the questionnaire form was submitted to Qatar University Institutional Review Board (QU-IRB). Appendix B: RESEARCH ETHICS APPROVAL shows the research ethics review exemption form which stated that QU-IRB reviewed all the research documents and assured that they met all the requirements and had been exempted from full ethics review. Also, all the research work should be related to the research ethics NO. QU-IRB 805-E/17.

3.5 Questionnaire Design

The Questionnaire was created in the English language, is attached in Appendix A: Questionnaire Form Unnecessary personal data, complicated, and repeated questions were avoided. The questionnaire was designed and performed through the following steps; the researcher reviewed different online resources that related to administrative controls on heat stress and Qataris the data to be connected to the construction sector in Qatar, then followed by multiple consultation sessions with the supervisor of this thesis and a specialist member at the Social and Economic Survey Research Institute at Qatar University (SESRI-QU). Also, a consultation session was conducted with experienced people to finalize the questionnaire form in a proper local practical form. The questionnaire was presented with a covering letter which described the scope of the study, the way of responding, the purpose of the study and the confidentially of the information in order to encourage the respondents to answer the questionnaire with confident.

The structured questionnaire was specially designed for the study and it consisted of three main sections:

1. The first section was a cover letter, which explained the determination and the aim of the study.
2. The second section was basic personal information about the respondents.
3. The third section was the main body of the questionnaire and it was divided into two fields (Attitude of people about heat stress toward work condition, and work condition practices in order to control heat stress.)

3.6 Data Measurement

For any measurement method, there is/are a proper technique/s that can be applied. This research includes ordinal scales that were used. An ordinal scale is a ranking data order that use integers in descending or ascending order. The numbers are allocated with the important level (1, 2, 3, 4, and 5) and do not show that the interval among scales are equal, nor do they indicate absolute numbers. They are only numerical labels. The following table illustrates the Likert Scale with the ordinal scales.

Table 3-1:Likert Scales & Ordinal Scales

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
Item	Very Important	Important	Moderately important	Slightly Important	Not Important
Item	Always	Often	Sometimes	Rarely	Never
Scale Level	5	4	3	2	1
Weight Value	100	80	60	40	20

3.7 Statistical Tests

The approaches that are used in order to perform data analysis are both qualitative and quantitative methods. Full utilization of analysis is based on using the software SPSS 22. The researcher would appropriate using the following statistical tools:

1- Frequencies and Percentage.

2- Spearman correlation for Validity.

3- One sample t-test.

4- Spearman's Rank correlation.

5- Kendall's Rank correlation.

For the reasons of using the previous statistical tests, the following delivery matrix table shows this purpose.

Table 3-2: Delievey matrix seasons od statistical tests

Statistical Test	Season of selection the statistical test
1. Frequencies and Percentage. 2. Spearman correlation for Validity. 3. One sample t-test.	The researcher followed the analysis procedure of the following studies: Nabil, I., & El-Riyati, A. (2015) and Zeedia, A., Ashour, Y. and Buhaisi, I. (2012).
4. Spearman's Rank correlation. 5. Kendall's Rank correlation.	The purpose of using Spearman's and Kendall's Rank correlation is to analyze the correlation between the stakeholders of Qatari construction sector. The reason that both correlation tests were used, is to check the differences between the coefficients of Spearman and Kendal tests from the prospective of which test is more conservative than the other. In order to support this purpose, the following studies are taking into consideration while analyzing the correlation analysis: Dindo, D., Demartines, N., & Clavien, P. A. (2004) and Fitzpatrick, S. L., Brightwell, J., Wittliff, J. L., Barrows, G. H., & Schultz, G. S. (1984).

3.8 Content Statistical Validity of the Questionnaire Questions

The validity content of the questionnaire was ensured by Spearman correlation test for validity. Spearman test is called criterion-related validity test, which measures the correlation value between each item in the field and the whole field.

Table C- 1(Appendix C: DETAIL TABLES) illustrates the coefficient values of Spearman test of the whole questions in the questionnaire. As it can be shown in the table, the p-value of all questions is less than 0.05, so it can be said that the field parts and the survey questions met the validity purpose and achieve the study target.

Chapter4 DATA ANALYSIS AND DISCUSSION

4.1 Introduction

The purpose of this chapter is to analyze the collected data through the questionnaire to provide a real understanding about the current role of heat stress management practices in the construction sector in Qatar.

4.2 Descriptive Statistics for Employees of Construction Sector in Qatar

1. Age

Figure 4-1 shows that 8% (12 respondents) of the respondents are" From 20-25", 49% (77 respondents) of the respondents are " From 25-35", 27% (43 respondents) of the respondents are" From 35-45", 11% (17 respondents) of the respondents are "From 45-55", and 5% (8 respondents) of the respondents are" From 56-60".

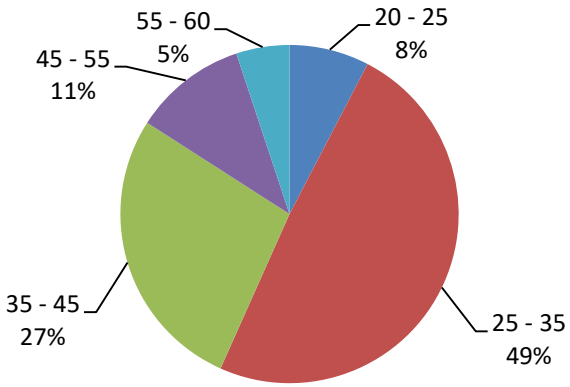

Figure 4-1: Ages distribution

2. Work experience in Qatar

Figure 4-2 shows that 21% (34 respondents) of the respondents work in Qatar "From 1-3 years", 17% (27 respondents) of the respondents work in Qatar "From 3-5 years", 20% (31 respondents) of the respondents work in Qatar "From 5-7 years", 22% (34 respondents) of the respondents work in Qatar "From 7-10 years", and 20% (31 respondents) of the respondents work in Qatar "More than 10 years".

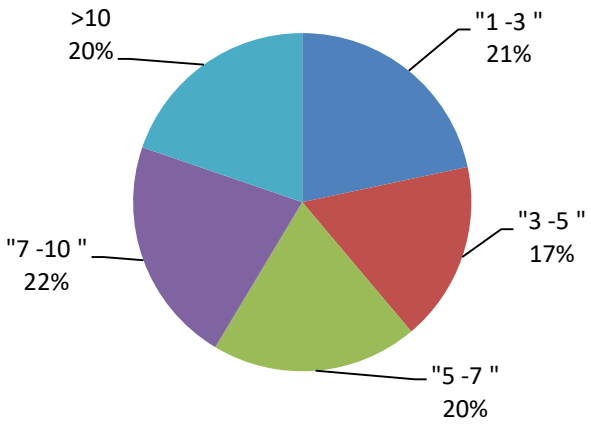

Figure 4-2: Work experience distribution in Qatar

3. Working in hot environment countries other than Qatar

Figure 4-3 shows that 33 % (52 respondents) of the respondents work in hot environment countries other than Qatar. On the other hand, 67% (105 respondents) of respondents reported that they did not work in hot environment countries other than Qatar.

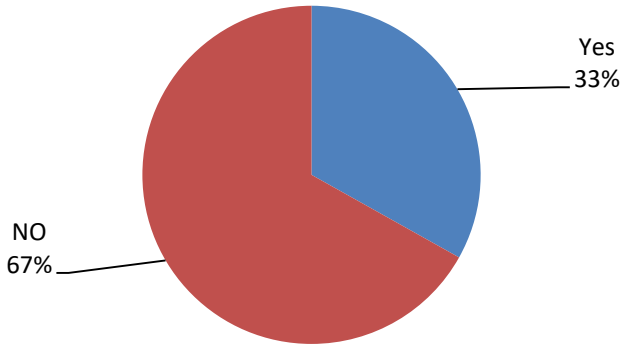

Figure 4-3: Working in hot environment countries

4. Work experience in hot countries other than Qatar

Figure 4-4 shows the frequencies the respondents who work in hot weather countries like Qatar's weather. The figure below shows that 67 of the respondents worked in hot weather countries distributed among 33 of them in United Arab Emirates, 18 respondents in Saudi Arabia, 7 respondents worked in Oman, and others(less than 5, separately) worked in Egypt, Kuwait, Bahrain and Sudan.

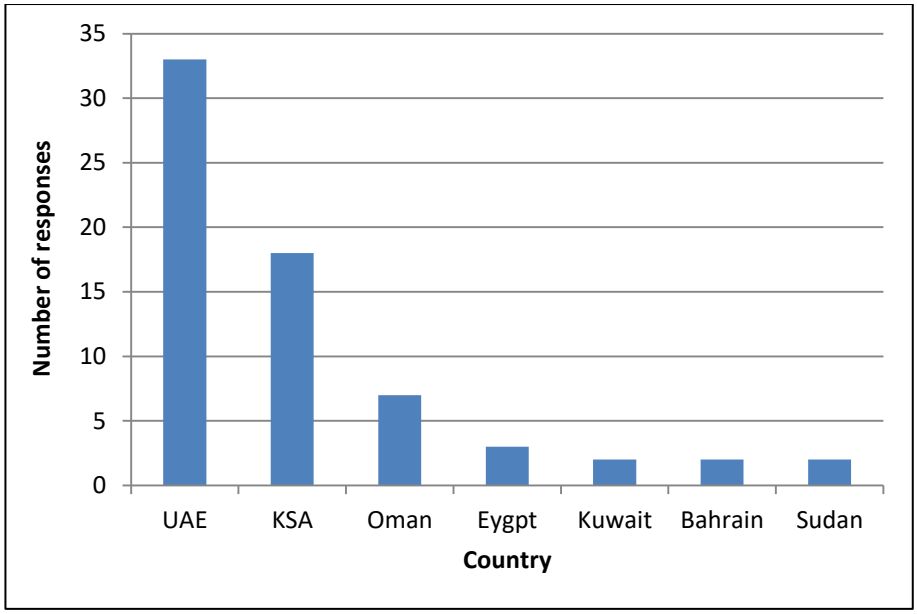

Figure 4-4: Number of responses for working in hot weather countries

5. Current job occupation

Figure 4-5 shows that 22% (35 respondents) of the respondents are “HSE Staff ", 20% (31 respondents) of the respondents are “Foreman ", 38% (60 respondents) of the respondents are “Engineers", and 20% (31 respondents) of the respondents are “Managers",

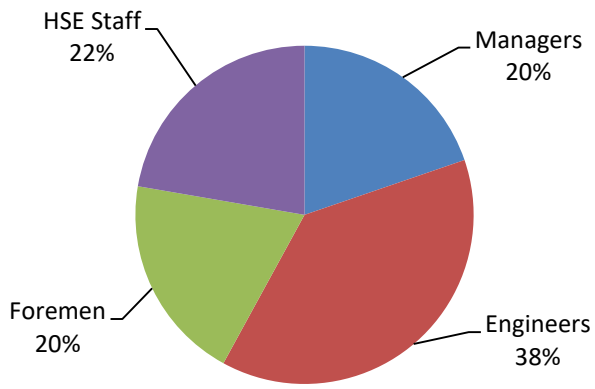

Figure 4-5: Job Occupation Percentages

6. Average shift-work time duration (hour / day)

Figure 4-6 shows that 19 % (30 respondents) of the respondents work "8 hours/ day" , 6% (10 respondents) of the respondents work "9 hours/day", 55% (86 respondents) of the respondents work "10 hours/day", 11% (17 respondents) of the respondents work "11 hours/day" and 9% (14 respondents) of the respondents work "more than or equal 12 hours/day".

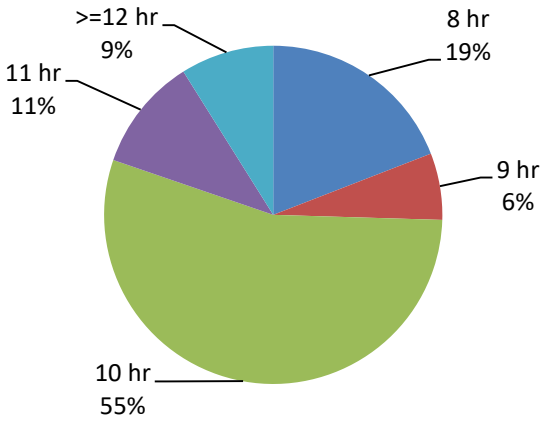

Figure 4-6: Average shift-work time duration (hour / day)

7. How many hours per day do you spend outdoor?

Figure 4-7 shows the frequencies of the working hours in outdoor condition. The results shows that the maximum outdoor work hours are 6 hours with 30 people, the minimum hours are 9 outdoor hours with 1 response.

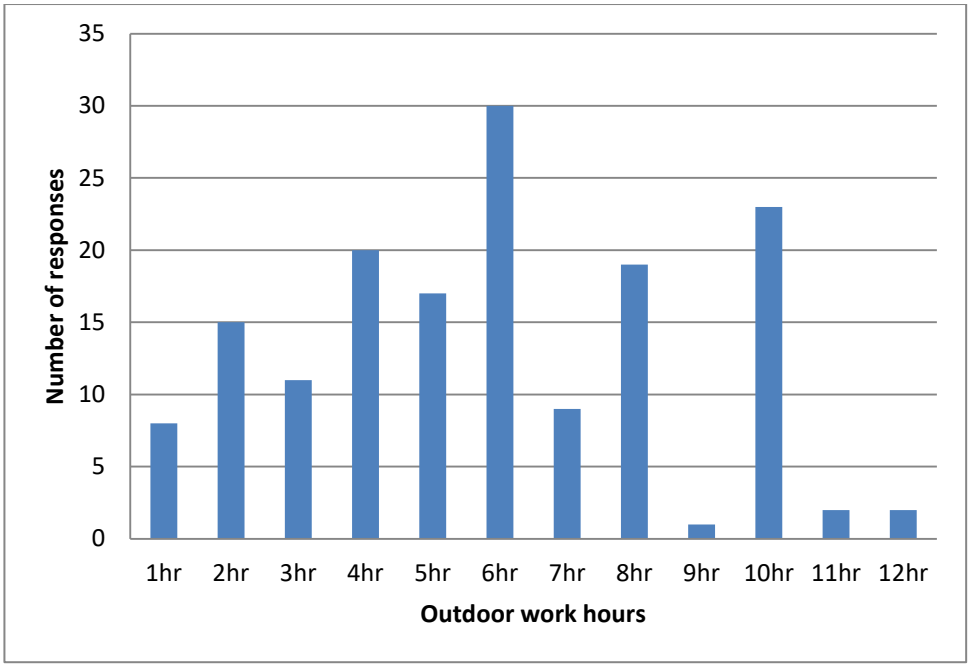

Figure 4-7: Number of responses for outdoor work hours

4.3 Research Hypotheses Analysis

In the following section, a one-sample t-test was used to test if the respondents agree, nuetral or do not agree with the content of the questions. If their opinions are positive which means that the weight of the answers is more than "80%" and the p-value(significant t-test value) is less than 0.05, so the respondents agree to the content of the questions. If the opinion of the respondent are positive which means that the weight of the answers is " less than 80% and more than 60%" and the p-value less (significant t-test value) is than 0.05, so the respondents nuetrally agree to the content of the questions. If the opinion of the respondent are negative which means that the weight of the answers is " less than 60% and more than 40%" and the p-value less (significant t-test value) is than 0.05, so the respondents nuetrally do not agree to the content of the questions. If the opinion of the respondent are negative which means

that the weight of the answers is "less than 40%" and the p-value less (significant t-test value) is than 0.05, so the respondents do not agree to the content of the questions.

4.3.1 Part# 2 "Attitude toward Work Condition"

Table 4-1 shows the following results:

The mean weight of Question 2 "Agreement with the condition of that the laborers should work in a proper weather condition" equals 4.50 (89.94%), t-test-value =32.64, and P-value = 0.000, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a positive value, so the mean value of this question is more significant than the hypothesis weight value 3. Therefore, the respondents significantly agreed to the context of this question.

The mean weight of Question 3 "Do you think that there is violation in work role under heat in Qatar?" equals 3.21 (64.20%), t-test-value =1.99, and P-value = 0.000, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a positive value, so the mean value of this question is more significant than the hypothesis weight value 3. Therefore, the respondents agreed neutrally to the context of this question.

The mean weight of the whole part "Attitude toward work condition" equals 3.84 (76.82%), t-test-value = 20.17, and P-value=0.049, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a positive value, so the mean value of this part is more significant than the hypothesis weight value 3. Therefore, the respondents agreed to the context of this part.

Table 4-1: Research Hypothesis of the part"Attitude toward work condition"

Question	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Agreement with the existing work rules for heat stress	3.82	76.31	0.95	10.80	0.00	2
2. Agreement with the condition of that the laborers should work in a proper weather condition	4.50	89.94	0.66	32.64	0.00	1
3. Agreement that there is a violation in work role under heat in Qatar	3.21	64.20	1.33	1.99	0.00	3
Total	3.84	76.82	0.52	20.17	0.049	

4.3.2 Part #3.1 "Work Practice – Performance Conditions of Working Time"

Table 4-2 shows the following results:

The mean weight of Question 1 "How much time do you spend in outdoor working zones" equals 3.83 (76.69%), t-test-value =11.29, and P-value = 0.000, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a positive value, so the mean value of this question is more significant than the hypothesis weight value 3. Therefore, the respondents often agree to the context of this question.

The mean weight of Question 3 "How much time do you spend working in confined or closed areas" equals 2.46 (49.17%), t-test-value =-5.81, and P-value = 0.000, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a negative value, so the mean value of this question is less significant than the hypothesis weight value 3. Therefore, the respondents rarely to sometimes agree to the context of this

question.

The mean weight of the whole part “Work Practice - performance conditions of working time” equals 2.92 (58.39%), t-test-value = -1.46, and P-value=0.15, P-value is greater than the significant level $\alpha = 0.05$. The test sign is a negative value, so the mean value of this part is less significant than the hypothesis weight value 3. Therefore, the respondents sometimes disagreed to the context of this part. However, P-value shows that this part is not significantly important to the section Work Practice.

Table 4-2: Reseach Hypothesis for performance conditions of working time

Question	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Working time period in outdoor zones	3.83	76.69	0.93	11.29	0.00	1
2. Working time period near to hot source	2.47	49.30	0.96	-7.00	0.00	2
3. Working time period in confined or closed zones	2.46	49.17	1.17	-5.81	0.00	3
Total	2.92	58.39	0.71	-1.46	0.15	

4.3.3 Part#3.2 “Work Practice - Conditions of Wearing PPE - How Often Do You Wear the PPE Items”

Table C- 2 (Appendix C: DETAIL TABLES) shows the following results:

The mean weight of Question 7 “wear Safety shoes” equals 4.69 (93.76%), t-test value =28.53, and P-value = 0.000, P-value is smaller than the significant level α = 0.05. The test sign is a positive value, so the mean value of this question is more significant than the hypothesis weight value 3. Therefore, the respondents always wear Safety shoes.

The mean weight of Question 8 “wear Coveralls (cotton)” equals 1.73 (34.65%), t-test value =-11.92, and P-value = 0.00, P-value is smaller than the significant level α = 0.05. The test sign is a negative value, so the mean value of this question is less significant than the hypothesis weight value 3. Therefore, the respondents rarely wear Coveralls (cotton).

The mean weight of the part “How often do you wear the following items” equals 3.94 (78.77%), t-test value = 19.45, and P-value=0.000, P-value is smaller than the significant level α = 0.05. The test sign is a positive value, so the mean value of this part is more significant than the hypothesis weight value 3. Therefore, the respondents often wear the items in this part.

4.3.4 Part#3.4 "Work Practice - How Often the Following Issues Are Reported in Job Site"

Table C- 3 (Appendix C: DETAIL TABLES) shows the following results:

The mean weight of Question 6 "reported Sweating in job site" equals 4.17 (83.44%), t-test-value =12.59, and P-value = 0.000, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a positive value, so the mean value of this question is more significant than the hypothesis weight value 3. Therefore, the respondents always reported Sweating in job site.

The mean weight of Question 8 "reported Syncope in job site" equals 1.78 (35.67%), t-test-value =-14.41, and P-value = 0.00, P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a negative value, so the mean value of this question is less significant than the hypothesis weight value 3. Therefore, the respondents rarely reported Syncope in job site.

The mean weight of the part "How often the following issues are reported in job **site**" equals 2.63 (52.55%), t-test value = -6.40, and P-value=0.000. P-value is smaller than the significant level $\alpha = 0.05$. The test sign is a negative value, so the mean value of this part is less significant than the hypothesis weight value 3. Therefore, the respondents rarely to sometimes report these issues in job site.

4.3.5 Part#3.5: "Work Practice - Importance Level of the Administrative Control Methods to Control Heat Stress"

In order to set the importance ranking level of the administrative control methods, one-sample t-tests were perform the 23 methods and based on 6 groups:

1. Group #1: consists of 157 respondents and include all respondents.

2. Group#2: consists of 31 respondents and include managers only.
3. Group#3: consists of 126 respondents and include engineers, foremen, HSE Staff.
4. Group#4: consists of 60 respondents and include engineer only.
5. Group#5: consists of 32 respondents and include foremen only.
6. Group#6: consists of 36 respondents and include HSE staff only.

Administrative controls for management of heat stress:

The following show the list of the most important administrative controls for heat stress issues in the Qatari construction sites:

- 1. Work stoppage
- 2. Frequent work break and Job rotation
- 3. Hydration (Provide unlimited potable drinkable water)
- 4. Provide calibrated temperature and humidity measuring instruments
- 5. Wearing fully enclosed clothes
- 6. Wearing light weight clothes
- 7. Wearing cotton clothes
- 8. Wearing cooling vest that have ice water for laborers
- 9. Using permeable PPE that allow sweating
- 10. Using fans for ventilation
- 11. Adequate acclimatization period
- 12. Provide temporary rest area with air conditioning
- 13. Provide mess hall
- 14. Provide light weight objects
- 15. Schedule hot jobs for the cooler part of the day or cooler part of the year

- 16. Using Flagging System
- 17. Using sun cream protection
- 18. Using glucose periodically
- 19. Prevent workers to drink hot drinks; tea, coffee...etc.]
- 20. Check the daily food of each labor
- 21. Provide heat stress preventative training
- 22. Frequent Labor department inspection
- 23. Frequent internal HSE inspection

Table 4-3 shows the following results for Group#1

The mean weight of Administrative Control # 3 in group#1 "Hydration (Provide unlimited potable drinkable water)" equals 4.48 (89.55%), t-test-value =24.22, and P-value = 0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this question is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is significantly important.

The mean weight of Administrative Control # 17 in group#1 "Using sun cream protection" equals 3.18 (63.69%), t-test value =1.76, and P-value = 0.00. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this question is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is moderately important.

The mean weight of the part#3.5 in group#1 "The important of the administrative control methods to control heat stress" equals 4.0 (80%), t-test value = 26.15, and P-value=0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is

positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Table 4-3: The important of the administrative control methods to control heat stress – Group#1 & the final results of ranking the administrative controls for groups

			Group#1 Analysis			Groups rank results					
Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	#1	#2	#3	#4	#5	#6
AC1	3.99	79.87	1.03	12.03	0.00	16	16	16	9	20	16
AC2	4.06	81.28	1.00	13.28	0.00	13	12	13	6	21	7
AC3	4.48	89.55	0.76	24.22	0.00	1	1	1	1	8	1
AC4	4.04	80.76	0.99	13.19	0.00	14	13	15	16	16	12
AC5	3.52	70.32	1.15	5.61	0.00	21	21	20	18	18	23
AC6	3.73	74.65	1.10	8.34	0.00	18	19	18	19	10	18
AC7	4.26	85.13	0.88	17.85	0.00	4	14	4	4	1	13
AC8	3.58	71.59	1.26	5.76	0.00	19	20	19	20	15	22
AC9	4.03	80.64	1.01	12.81	0.00	15	15	14	13	2	17
AC10	4.35	87.01	0.88	19.31	0.00	2	9	2	2	5	3
AC11	4.17	83.48	1.00	14.60	0.00	11	3	11	15	6	10
AC12	4.18	83.57	0.86	17.20	0.00	9	11	9	10	12	5
AC13	4.20	83.95	0.87	17.33	0.00	8	7	8	11	9	11
AC14	3.96	79.10	0.92	12.99	0.00	17	17	17	17	17	14
AC15	4.25	85.10	0.97	16.26	0.00	6	2	6	12	3	6
AC16	4.31	86.24	1.02	16.05	0.00	3	4	3	7	7	2
AC17	3.18	63.69	1.31	1.76	0.04	23	23	23	23	23	21
AC18	4.16	83.18	0.92	15.85	0.00	12	10	10	14	4	9
AC19	3.36	67.18	1.22	3.68	0.00	22	22	22	22	22	19
AC20	3.54	70.70	1.14	5.91	0.00	20	18	21	21	19	20
AC21	4.22	84.49	0.84	18.22	0.00	7	5	7	5	14	8
AC22	4.17	83.31	0.92	15.90	0.00	10	6	12	8	13	15
AC23	4.26	85.26	0.95	16.32	0.00	5	8	5	3	11	4
Total	4.00	80.00	0.48	26.15	0.00						

Table C- 4 (Appendix C: DETAIL TABLES) shows the following results for Group#2

The mean weight of Administrative Control # 3 in group#2 “Hydration (Provide unlimited potable drinkable water)” equals 4.55 (90.97%), t-test value =12.77, and P-value = 0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this question is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is significantly important.

The mean weight of Administrative Control # 17 in group#2 “Using sun cream protection” equals 2.97 (59.35%), t-test value =-0.12, and P-value = 0.91. P-value is more than the significant level $\alpha = 0.05$, the test sign is negative, so the mean value of this question is less than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is moderately important, but P-value shows that it is not significantly important to the whole part.

The mean weight of the part#3.5 in group#2 “The important of the administrative control methods to control heat stress” equals 3.98 (79.59%), t-test value = 10.19, and P-value=0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Table C- 5 (Appendix C: DETAIL TABLES) shows the following results for Group#3

The mean weight of Administrative Control # 3 in group#3 “Hydration (Provide unlimited potable drinkable water)” equals 4.46 (89.21%), t-test value =20.84, and P-value = 0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this question is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is significantly important.

The mean weight of Administrative Control # 17 in group#3 “Using sun cream protection” equals 3.24 (64.76%), t-test value =2.12, and P-value = 0.04. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this question is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is moderately important.

The mean weight of the part#3.5 in group#3 “The important of the administrative control methods to control heat stress” equals 4.01 (80.13%), t-test value = 24.35, and P-value=0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Table C- 6 (Appendix C: DETAIL TABLES) shows the following results for Group#4

The mean weight of Administrative Control # 3 in group#4 “Hydration (Provide unlimited potable drinkable water)” equals 4.45 (89.00%), t-test value =14.61, and P-value = 0.00. P-value is less than the significant level $\alpha = 0.05$, the test sign is

positive, so the mean value of this Administrative Control is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is important.

The mean of Administrative Control # 17 in group#4 “Using sun cream protection” equals 3.02 (60.33%), t-test value =0.10, and P-value = 0.92. P-value is more than the significant level α = 0.05, the test sign is positive near to zero, the mean value of this question is equal not significantly the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is moderately important, but P-value shows that it is not significantly important to the whole part.

The mean weight of the part#3.5 in group#4 “The important of the administrative control methods to control heat stress” equals 3.92 (78.41%), t-test value = 14.83, and P-value=0.000. P-value is less than the significant level α = 0.05, the test sign is positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Table C- 7 (Appendix C: DETAIL TABLES) shows the following results for Group#5

The mean weight of Administrative Control # 7 in group#5“Wearing cotton clothes” equals 4.39 (87.74%), t-test value =8.40, and P-value = 0.00. P-value is less than the significant level α = 0.05, the test sign is positive, so the mean value of this Administrative Control is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is important

The mean weight of Administrative Control # 17 in group#5 “Using sun cream protection” equals 3.29 (65.81%), t-test value =1.01, and P-value = 0.32. P-value is

more than the significant level α = 0.05, the test sign is positive near to zero, the mean value of this Administrative Control is equal not-significantly the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is moderately important, but P-value shows that it is not significantly important to the whole part.

The mean weight of the part#3.5 in group#5 “The important of the administrative control methods to control heat stress” equals 3.98 (79.69%), t-test value = 10.78, and P-value=0.000. P-value is less than the significant level α = 0.05, the test sign is positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Table C- 8(Appendix C: DETAIL TABLES) shows the following results for Group#6

The mean weight of Administrative Control # 3 in group#6 “Hydration (Provide unlimited potable drinkable water)” equals 4.69 (93.71%), t-test value =15.80, and P-value = 0.000. P-value is less than the significant level α = 0.05, the test sign is positive, so the mean value of this Administrative Control is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is significantly important.

The mean weight of Administrative Control # 5 in group#6“Wearing fully enclosed clothes” equals 3.37 (67.43%), t-test value =1.97, and P-value = 0.03. P-value is less than the significant level α = 0.05, the test sign is positive, so the mean value of this Administrative Control is more significant than the hypothesis value 3. Therefore, the respondents agreed that this Administrative Control is significantly “moderately important”.

The mean weight of the part#3.5 in group#6 “The important of the administrative control methods to control heat stress” equals 4.17 (83.36%), t-test value = 19.93, and P-value=0.000. P-value is less than the significant level $\alpha = 0.05$, the test sign is positive, so the mean value of this part is more significant than the hypothesis value 3. Therefore, the respondents agreed that this part is important.

Groups rank with the vision of using different administrative controls for heat stress

Table 4-3 shows the ranking order of the importance request of using the 23 administrative controls as mentioned in the same table for the whole research groups (All participants, Managers, Site personnel staff, Engineers, Foremen, HSE Staff).

Agreement between groups about importance of administrative control methods:

In order to compare the agreement of the previous groups toward the importance of using administrative controls, Spearman rank correlation & Kendall rank correlation are used to correlate or check the agreement between the following groups:

1- Group #2 (Managers) and Group #3 (Site Workers)
2- Group #2 (Managers) and Group #4 (Engineers)
3- Group #2 (Managers) and Group #5 (Foremen)
4- Group #2 (Managers) and Group #6 (HSE Staff)
5- Group #4 (Engineers) and Group #5 (Foremen)
6- Group #4 (Engineers) and Group #6 (HSE Staff)
7- Group #5 (Foremen) and Group #6 (HSE Staff)

Table 4-4 shows the coefficient of Kendall and Spearman correlation to illustrate how much agreement correlation bond between the answers of Managers, Site Workers, Engineers, Foremen and HSE Staff. In comparison between Kendall and Spearman coefficient, they are consistent and show the correlation between every two groups. However, the values of Kendall coefficients are always smaller than the Spearman coefficient values. By comparing the values of Kendal & Spearman coefficient for Managers vs. HSE Staff, the values are 0.837 and 0.676 consequently. There is a huge difference between both values. In this case, when we examine the table, we find out that there are lots of ranking which are basically matching the same terminology, it is understood in the statistics that Kendall's tau is conservative measure while Spearman's tau does not handle duplicates or ties measures, we can see specifically that the correlation is there but using Kendall case is much weaker correlation than the Spearman case for the specific example of comparing managers to HSE Staff with Kendall's tau value equals to 0.676 and Spearman's tau equals to 0.837. Therefore, we rely on Kendall's tau because statistically is significantly reflect the real correlation between groups while Spearman's values are always overestimated values. The coefficient results are between 1 and 0 or 0 and -1. As long as the value is reaching to 1, this means that there is substantial agreement correlation between the answers of each group and vice versa for the situation of reaching the value -1. The Kendall coefficient value of groups (Manager -- site worker), (Managers – Engineers) and (Managers – HSE Staff) are 0.715, 0.534, 0.676, consecutively. Therefore, these results show that there is a moderate correlation between the managers with site worker, engineers, and HSE Staff. Also, the correlation of groups Site Workers – Engineers, Site Workers – Foremen and Site

Worker – HSE Staff will not be discussed since Engineers, Foremen and HSE Staff are already included within Site Workers group. On the other hand, the results show that there is a slight agreement between the answers of Foremen with HSE Staff, Managers, and Engineers; The Kendall coefficient are 0.344, 0.415 and 0.344 consecutively. This leads us to the fact that the Foremen has a performance target with less safety performance, but HSE Staff, Managers and Engineers are always looking to safety target which most of the time control and limit the performance level.

Table 4-4: Kendall and Spearman correlation coefficient

	Managers	Site Workers	Engineers	Foreman	HSE Staff
Kendall's tau_b					
Managers	1.00	0.715	0.534	0.415	0.676
Site Workers		1.00			
Engineers			1.00	0.344	0.621
Foreman				1.00	0.344
HSE Staff					1.00
Spearman's rho Coefficient					
Managers	1.00	0.851	0.713	0.593	0.837
Site Workers		1.00			
Engineers			1.00	0.464	0.796
Foreman				1.00	0.492
HSE Staff					1.00

4.4 Descriptive Analysis for Certain Questions in the Questionnaire

4.4.1 Par#3.1 Analysis of Question "Do You Ask Laborers to Wear One or more of the Items Described in Previous Question?"

Table 4-5 shows that 75.2 % of the respondents answer always " ask laborers to wear one or more of the items described in previous Question", 17.2% of the respondents Often " ask laborers to wear one or more of the items described in previous Question, 6.4% of the respondents sometimes" ask laborers to wear one or more of the items described in previous Question.

For explanation: the words "Previous Question" is related to Part #3.1 "Work Practice – Performance Conditions of Working Time"

Table 4-5: Analysis of question: " Do you ask laborers to wear one or more of the items described in previous Question"

Items	Frequency	Percentages
Always	118	75.2
Often	27	17.2
Sometimes	10	6.4
Rarely	2	1.2
Never	0	0.0
Total	157	100

4.4.2 Part#3.4: Work Practice – the Most Fluids Consumed during Work Time

Table 4-6 shows that 42.7 % of the respondents so that " Warm and/or Cold Water " are the most fluids consumed during the work time, 8.3% of the respondents so that " Oral hydration salt " are the most fluids consumed during the work time, 10.2% of the respondents so that " Glucose" are the most fluids consumed during the work time, 10.8% of the respondents so that " Tea and Coffee, Water " are the most fluids consumed during the work time, and 16.6% of the respondents so that " Water, Glucose, Oral hydration salt " are the most fluids consumed during the work time.

Table 4-6: Frequency of the most consumed fluids during the work time

The most consumed fluids during the work time	Frequency	Percentages
Warm and/or Cold Water	67	42.7
Oral hydration salt	13	8.3
Glucose	16	10.2
Tea and Coffee, Water	17	10.8
Lemon juice	9	5.7
Soft Drinks	8	5.1
Water, Glucose, Oral hydration salt	26	16.6
Pocari sweat, Orange Jucie	1	0.6
Total	157	100.0

4.4.3 Part#3.6: Work Practice – Using Different Administrative Control Methods Under Different Heat Index Condition

Administrative controls for heat stress for Heat Index period >54 °C

Figure 4-8 shows the frequencies of respondents for heat index >54 °C. It is clear that the method (stoppage of work) is the major accepted method for this period where 95 of the participants prefer to stop work when the temperature rises above 54. This result indicates the importance of stopping the work for this period of heat index, while the remaining of the participants distributed on the remaining 22 of administrative controls. All of the respondents for these 22 methods are between periods 0-10 or 10-20. For example, 20 respondents agreed to use "Wearing cooling vest that has ice water for laborers" at this heat index period, 18 respondents agree to use "Prevent workers to drink hot drinks; tea, coffee...etc." Therefore, we conclude from the above that there is a preference to stop the work when heat index rise above >54 °C because significant adverse impacts on the workers at the construction sites which are related to the heat illnesses. However, the responses toward other administrative controls are still giving close importance to use them which indicates that we should consider them for >54 °C.

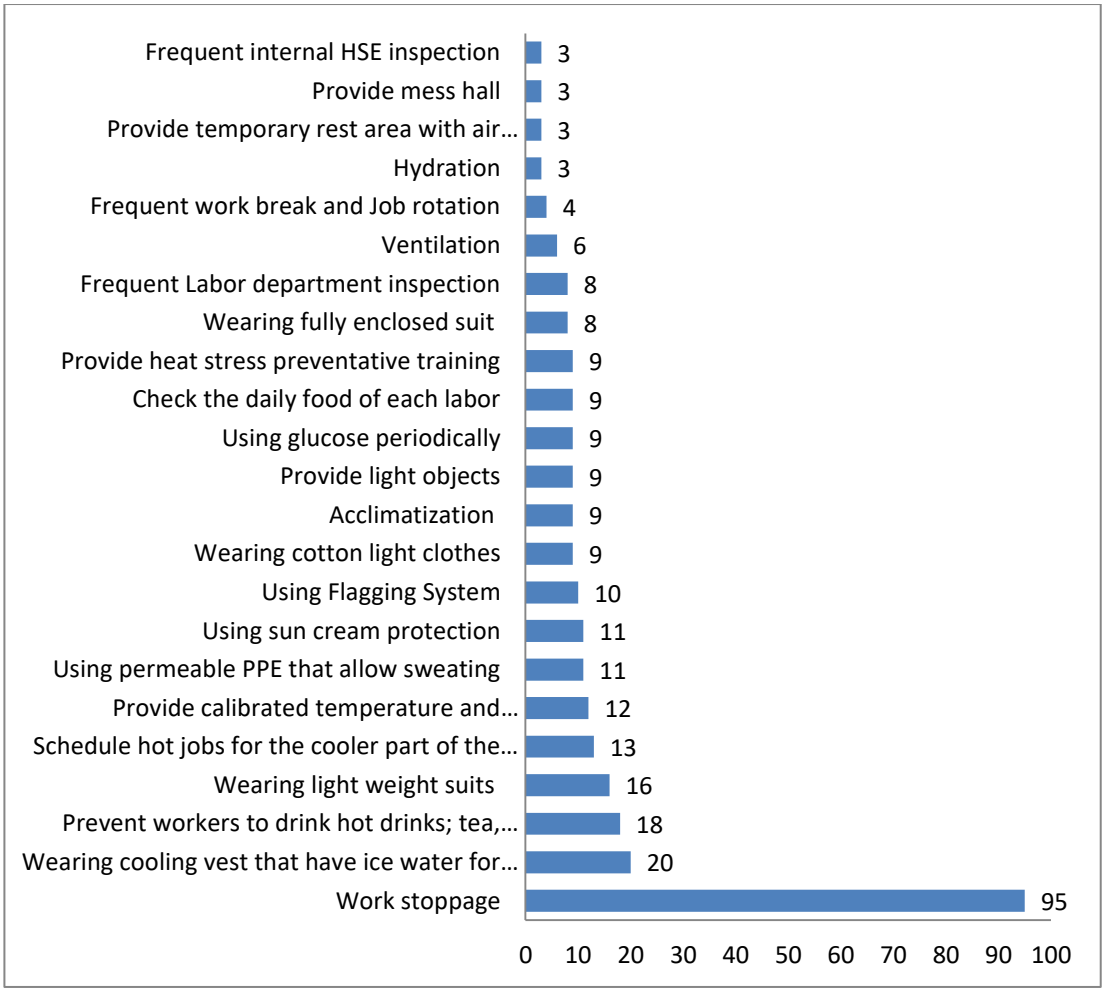

Figure 4-8: Number of reponses for using different administrative controls for heat index >54 °C

Administrative controls for heat stress for Heat Index period (39°C-53°C)

During this heat index period, the responses for using the administrative controls varied from 81 to 22. The administrative rule that the participants concentrated on is the use of the sun cream because it has a positive effect on reducing the heat impact. Hence, there was a convergence between the responses in the category from 50 to 70 and from 30 to 50. During the category period 50 to 70, participants confirm the need for using "Frequent work break and Job rotation" to renew the energy of the worker body. And the followed answers concentrated on "Wearing lightweight clothes" and

give them light tools as well as using "permeable PPE that allow sweating" and "Provide temporary rest area with air conditioning." During the category period 30 to 50, most of the participants focused on the importance of following the necessary guidelines to avoid heat stress such as wearing fully enclosed clothes, using glucose, measuring the heat index, provide ventilation, work stoppage, hydration, acclimatization and re-scheduling the work. It should be noted that 39 participants pointed out the possibility of stopping the work during this period, which indicating that the suspension of work should not be limited only to the period of temperature 54 °C as usually the performed case in Qatar.

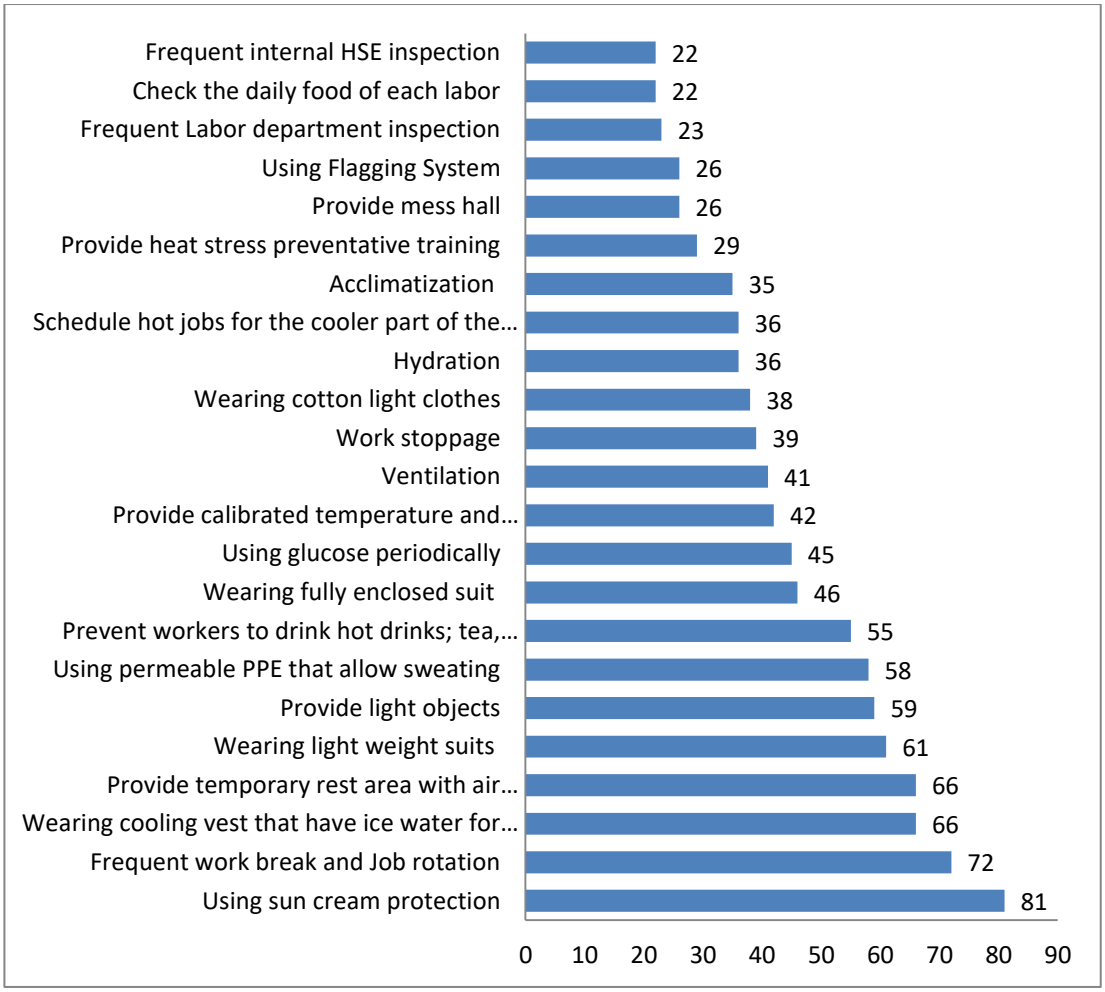

Figure 4-9: Number of responses for using different dministrative controls for Heat Index (39°C-53°C)

Administrative controls for heat stress for Heat Index period (27°C-31°C) & (32°C-38°C)

Figure 4-10 and Figure 4-11 show the number of responses for using different administrative controls for heat indices (32°C-38°C and 27°C-31°C) for the use of administrative controls of heat stress. It is clear that there is a high similarity between the answers for these two thermal groups, this indicates to the closest association between them and the published vision that are both have normal and moderate thermal effect for the construction workers. It is also clear that the confirmation of the

participants on the rule (Wearing fully enclosed clothes) because they believe completely in the existing of the cool weather for these heat indices periods, which indicates their emphasis on warming the body of the worker as well as the use of the rule (Wearing lightweight clothes) to reduce the heat effect on the body. And, they consider using cotton clothes which have positive effect for reducing the heat effect. The opinions of the participants in using (Ventilation, Using permeable PPE that allow sweating and Wearing cotton clothes) were slightly differentiated with a slight increase in the responses at the heat index period (32°C-38°C) due to their belief in the probability for the heat stress illnesses at this heat period. In the span category from 0 to 10, it is clear for both heat index periods that the confirmation of the participants on the use of other administrative control methods was concentrated for both periods, which shows the importance of these administrative controls for heat indices (32°C-38°C and 27°C-31°C).

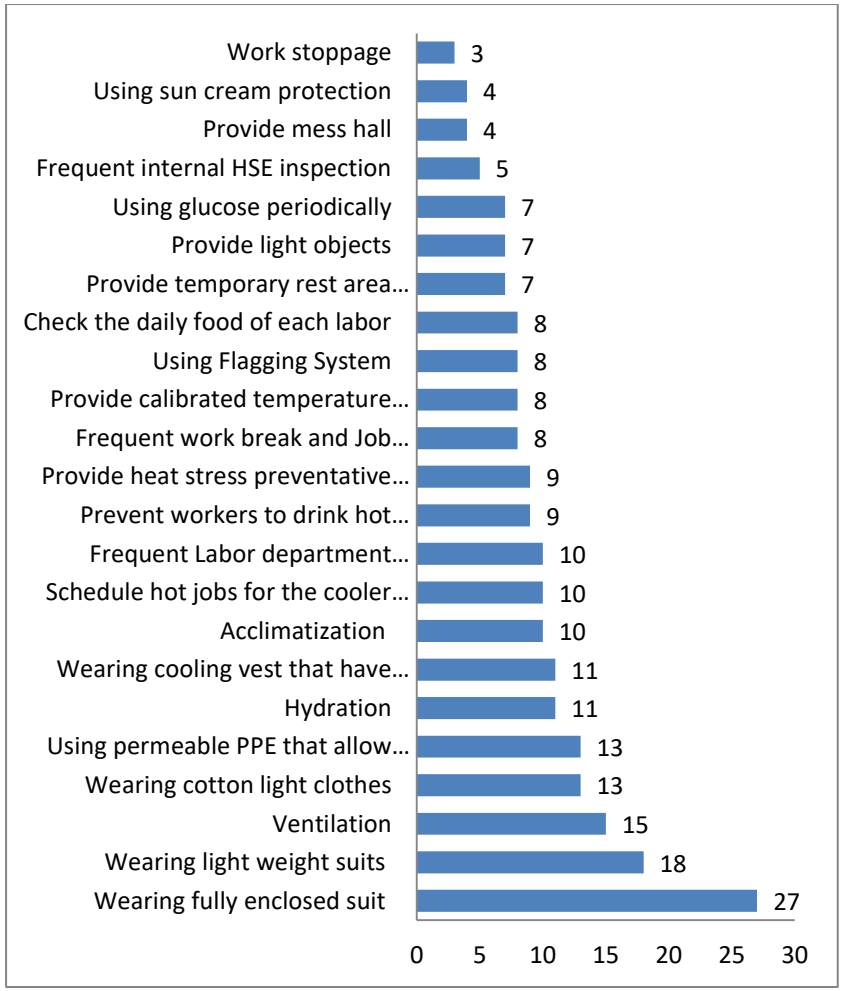

Figure 4-10: Number of reponses for using different administrative controls for Heat Index (32°C-38°C)

Figure 4-11: Number of reponses for using different administrative controls for Heat Index (27°C-31°C)

Administrative controls for heat stress for Heat Index period (all condition)

Figure 4-12 shows the number of responses for using the 23 administrative control methods for heat stress under all conditions of weather. It is clear that the responses were focused on this heat index period where 51% of the total answers are received for this all conditions of weather for (Part#3.7: Work Practice – Using Different Work-rest Rate under Different Heat Index per Different Work Rate Rotation). The responses were varied between the category periods from 0 to 120. For period 100 to 120, people believe to use the administrative controls (Frequent internal HSE inspection, Frequent Labor department inspection, provide heat stress preventative training, Check the daily food of each labor, Using Flagging System and Provide mess hall). These selected methods are essential under all conditions of weather for the following reasons:

- Follow up the commitment of people in the construction sites to follow the work by using frequent internal HSE inspection and frequent labor department inspection as well as providing heat stress preventative training and monitoring the daily food of each labor to educate workers about the importance of prevention of heat-related illnesses during work.
- It is necessary to use (Using Flagging System and Provide mess hall) during all working time for the advantage of follow-up the heat index status and use mess hall for cooling the laborers' body.

Also, for category 80 to 100 and 60 to 80, the participants focused on the other administrative controls. This result is a confirmation of what we have just stated on the importance of using most of the administrative control rules in all weather conditions. If we look at the category periods of less than 60, the answers were

focused on the use of the following administrative controls; using sun cream protection, wearing cooling vest that has ice water for laborers, wearing lightweight clothes and fully enclosed clothes and work stoppage. The primary reason for why people believe in less significant important for using these five administrative controls because they are not practical for usage them for all weather conditions and due to other specific reasons, as follows:

- For using sun cream protection due to its little useful from the administrator point view. Also, it will be costly if this method is always applied for all conditions.
- For wearing cooling vest that has ice water for laborers due to its limited availability in the local market and costly if this method will be used for all the workers.
- For wearing lightweight clothes and fully enclosed clothes due to the inability to control personal decisions for clothes wearing.
- It is important to mention that there is little confirmation for the administrative control (Work stoppage) with 17 responses. These responses believe that the work should be stopped at any condition and should not be applied only when the temperature rises above 54°C. While others think that this method should be limited and it is not practical to stop the work for all situations which will lead to delay the work schedule if more stoppage periods are performed at the project.

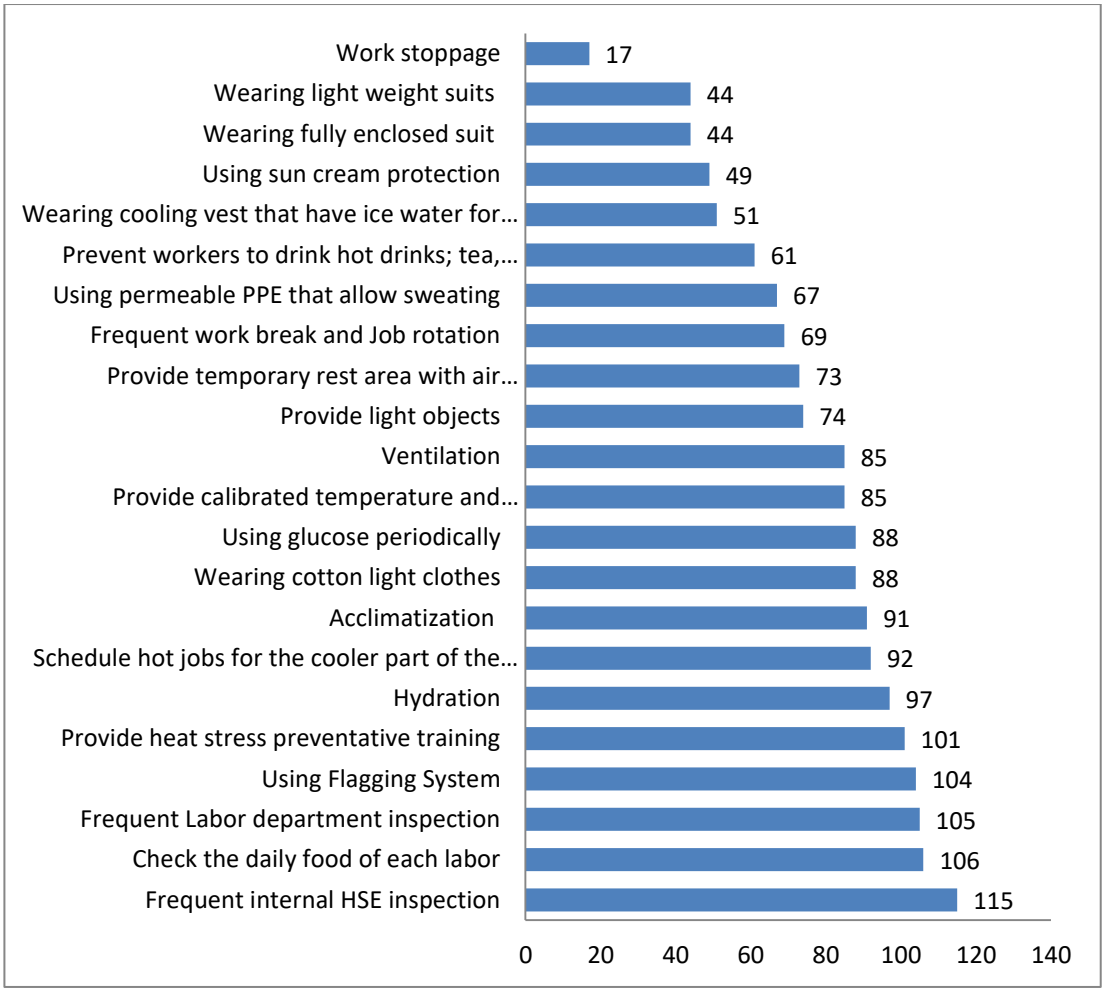

Figure 4-12: Number of reponses for using different administrative controls for Heat Index (All Conditions)

Work Stoppage under different Heat Index periods

Figure 4-13 shows the number of responses for using the administrative control (Work Stoppage) under different heat index periods(>54°C, 39°C-53°C, 32°C-38°C, 27°C-31°Cand all conditions). The results show that the majority of people (95 responses) accept to stop the work for heat index >54 °C which is the current applied condition in Qatar. However, others accept to stop work for less than 54°C because they believe that the severe condition of work should not be applied only when the

heat index is bigger 54°C, where 39 people believe that there is a possibility to get heat-related illness for the heat index 39°C-53°C.

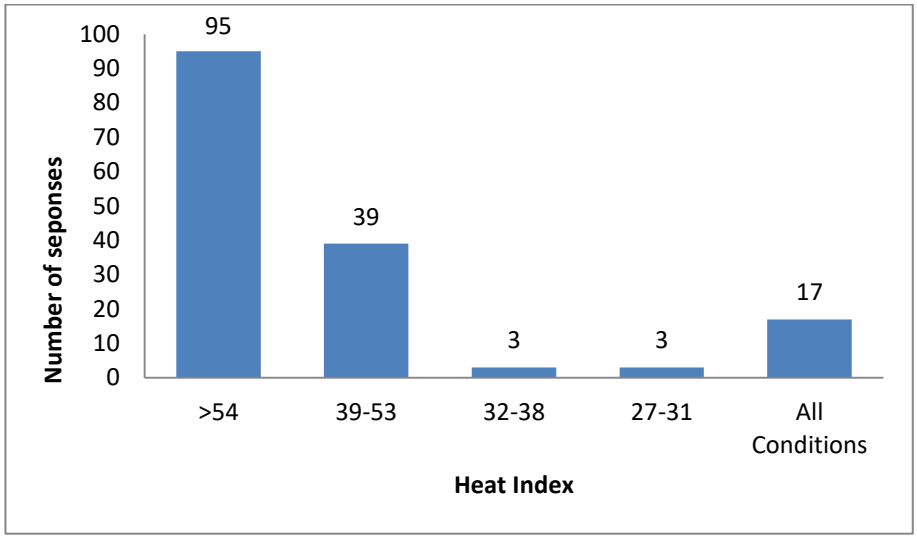

Figure 4-13: Number of responses for using work stoppage under different heat index conditions

Work break and Job rotation under different Heat Index periods

Figure 4-14 shows the Number of responses for using frequent work break and Job rotation for different heat index periods. The results show that 72 of the respondents for this question prefer to intensify the use of this method in the summer period. While others (69 people) prefer to use this technique in all weather conditions because of the significant impact on renew the energy of the body. There is few responses for supporting slightly the use this administrative method for >54 °C, 32°C-38°C and 27°C-31°C, which indicate the slight significant important to use frequent work break and Job rotation for these conditions.

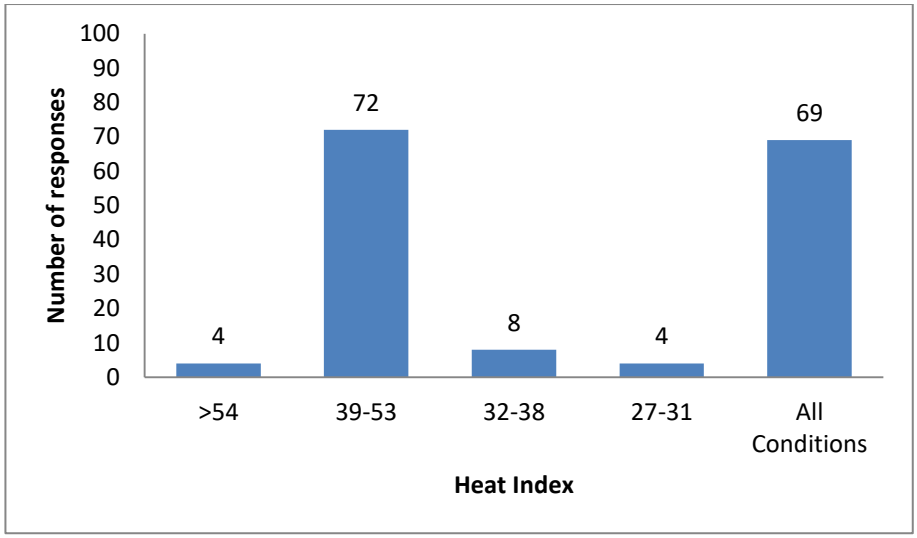

Figure 4-14: Number of responses for work break and Job rotation under different heat index conditions

Hydration under different Heat Index periods

Figure 4-15 shows the numbers of responses for using the administrative control (Hydration) under different heat index periods. The results show that about 60% of the respondents preferred using this method in all weather conditions, while others (about 25%) prefer to use this method for heat index 39°C-53°C because of the impact on the body and hence decreasing the body's fluids. Therefore, the workers should drink plenty amount of water to renew the body energy and replenish the lost fluids during the work. And there are few responses for using the hydration for heat index conditions 32°C-38°C and 27°C-31°C.

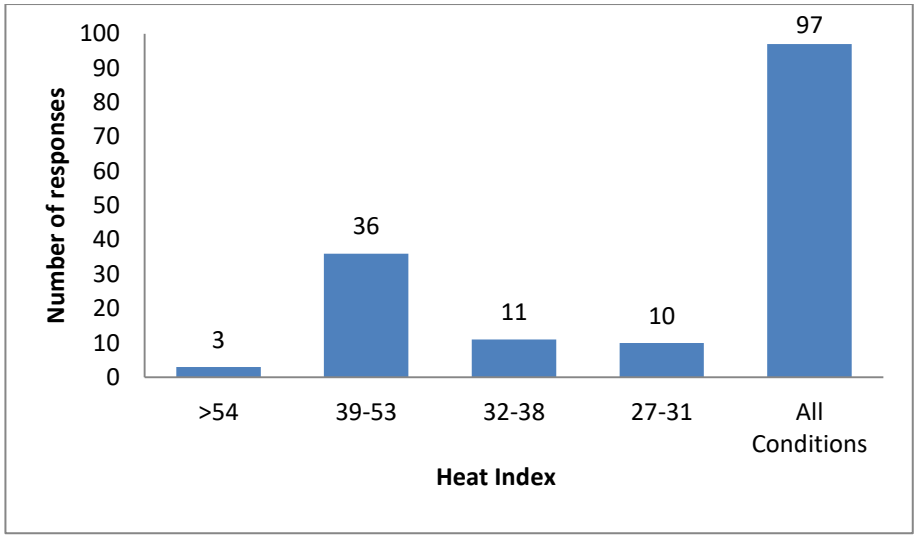

Figure 4-15: Number of responses for Hydration under different heat index conditions

Providing calibrated temperature and humidity measuring instruments under different Heat Index periods

Figure 4-16 shows the number of responses for using heat index instruments under different heat index periods. 85 of the respondents (about 55% of the total participants) agreed to use this method for all conditions and this lead us to the importance of the continuous availability of this administrative control method to check the daily weather condition. While others (42 of the respondents) believe that this should be used only when the heat index is between 39°C-53°C because the summer season in Qatar is the most severe hot weather condition for work, and the weather should be monitored for this period. There are few responses for the rest of heat index periods, and this is because they believe that the heat stress is not only connected to the heat index period 39°C-53°C and it might occur for the other heat index periods, so we should not skip this method for any specific heat stress period.

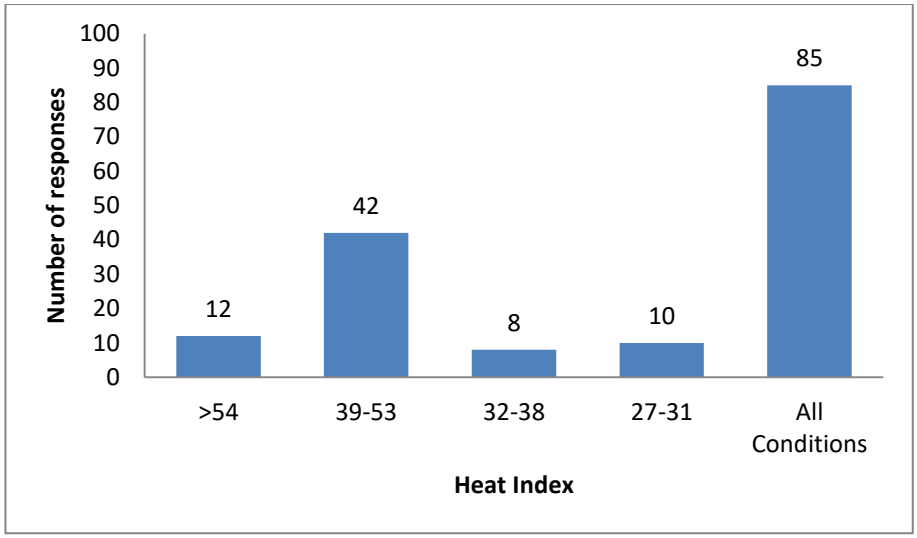

Figure 4-16: Number of responses for providing calibrated temperature and humidity measuring instruments under different heat index conditions

Wearing fully enclosed suit, lightweight suit and cotton under different Heat Index periods

The following three figures describe the number of responses for wearing different kind of clothes for different heat index periods. The results show that 44 of the respondents agreed to use full close suits and lightweight clothes for all heat index conditions. In comparison with using cotton cloths, the result jumps to 88 people who agreed to use cotton cloths for all heat index conditions. The reason for this jump is that cotton clothes absorb the heat and water, so cotton clothes are practically appropriate for the purpose of controlling heat stress. For heat index period 39°C-53°C, 61 people agreed to wear lightweight clothes because they believe that lightweight cloths allow the proper evaporation process of sweating between skin and environment. However, around 40 of the respondents believe in wearing fully enclosed and cotton clothes because they believe that we should do our best to cover

the body from the sun radiations and use as well cotton clothes. For periods 27°C-31°C and 32°C-38°C, the number of responses are focused for wearing fully enclosed at these heat index periods. This reason is that these people believe this period is mixed with cold weather, so it is a good idea to warm the body and wear full enclosed cloths.

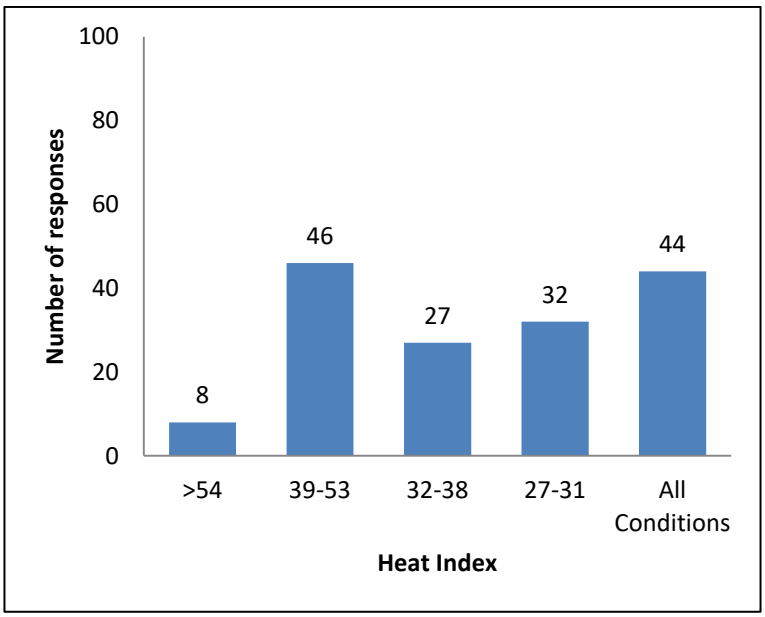

Figure 4-17: Number of responses for wearing fully enclosed clothes under different heat index conditions

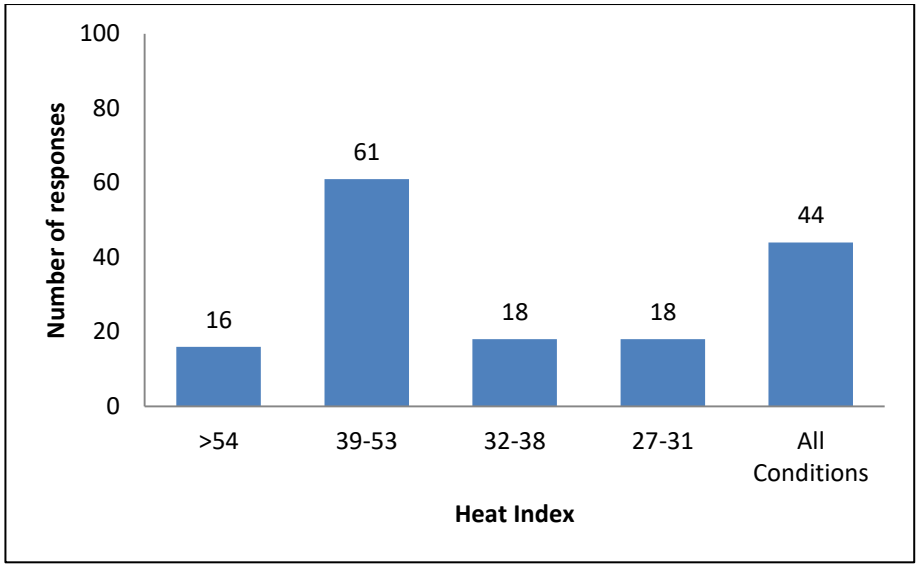

Figure 4-18: Number of responses for wearing light weight suit under different heat index conditions

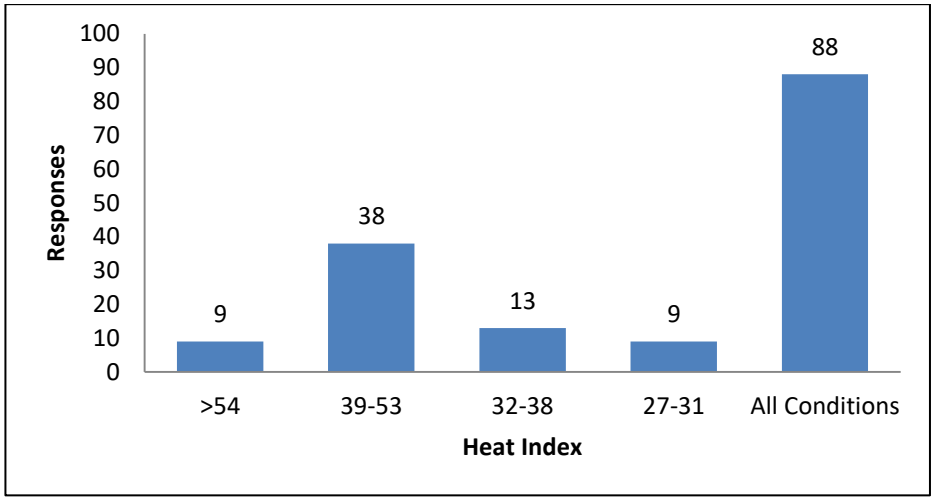

Figure 4-19: Number of responses for wearing cotton clothes under different heat index conditions

Figure 4-20 describes the frequency of wearing the cooling vest for different heat index periods. The result shows that 66 of the respondents agreed to use cooling vest for the heat index period 39°C-53°C because they believe in the importance value of using the cooling vest to control heat stress during this period. Others (51 people) agreed to use cooling vest for all condition of weather due to the workload exertion which always add stress on the body, so by using cooling vest, the result reduce these adverse effects. A few people believe in using it for periods >54 °C, 32°C-38°Cand 27°C-31°C.

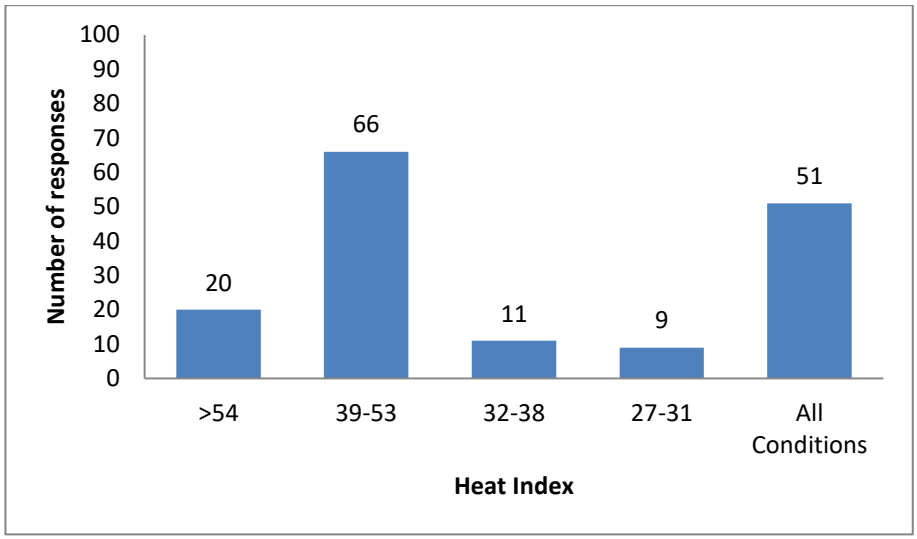

Figure 4-20: Number of responses for wearing Cooling vest under different heat index conditions

Using fans for ventilation under different Heat Index periods

Figure 4-21 shows the number of responses for using fans for ventilation under different heat index conditions. About 50% people (85 people) agreed to use this approach for all weather conditions. This result indicates the importance of using the

fans at workplaces to produce air movement in confined places that have less air movement. 41 people confirm to use fans for the heat index period 39°C-53°C because they believe that the summer period is the extreme hot weather, and the air movement will be affected as well. Therefore, these people assure to use this approach for this purpose.

Acclimatization, mess hall, Scheduling of jobs activities, glucose periodically, and flagging system under different Heat Index periods

Figure 4-22, Figure 4-23, Figure 4-24, Figure 4-25, and Figure 4-26 show the frequencies of using acclimatization, mess hall, Scheduling of jobs activities, glucose periodically, and flagging system under different heat index periods. The graphs' results show that about 80 people per each graph (50% of the respondents per each graph) agreed to use these approaches in all weather conditions due to their importance to reduce the negative impact of heat stress. However, others (about 30 people) agree to use these approaches for the heat index period 39°C-53°C except using flagging system where the number of responses was 22 people. However, few number of people use these approaches for heat index periods >54 °C, 32°C-38°C and 27°C-31°C. We can conclude that these control methods are critical methods to control heat stress and should be used at any time, but the concern should increase to use them in the summer season.

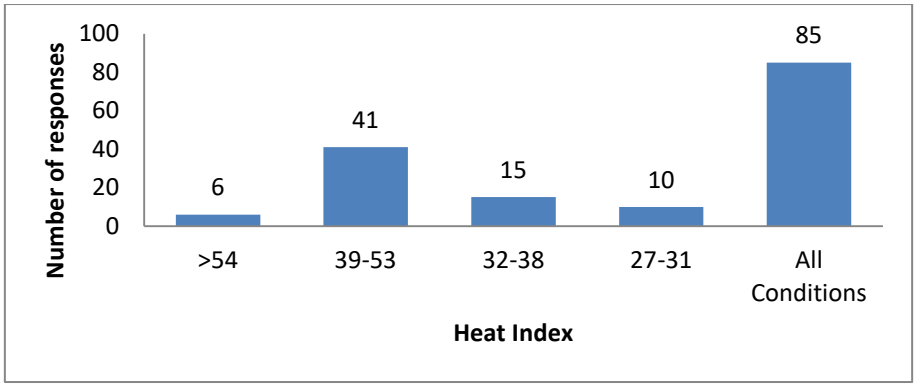

Figure 4-21: Number of responses for using fans for ventilation under different heat index conditions

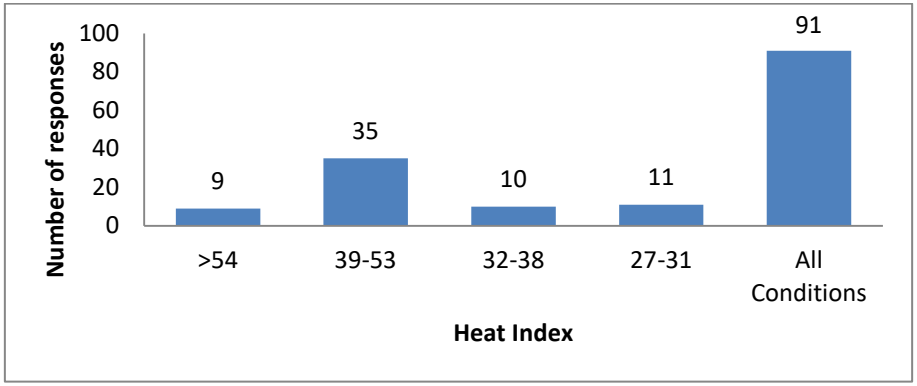

Figure 4-22: Number of responses for using adequate acclimatization period under different heat index conditions

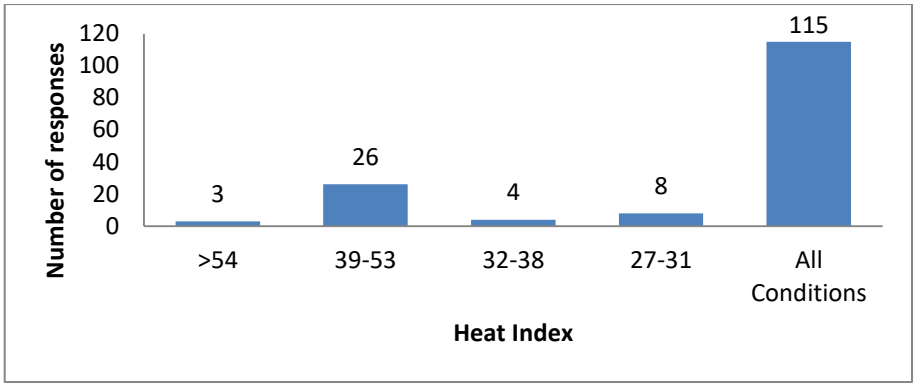

Figure 4-23: Number of responses for providing mess hall under different heat index conditions

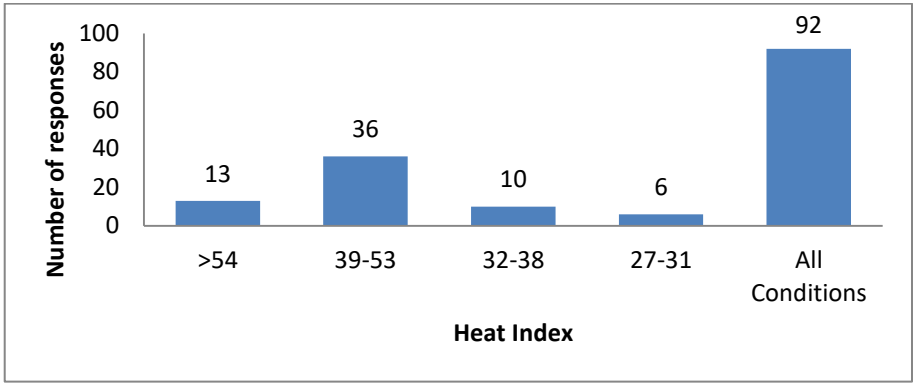

Figure 4-24: Number of responses for scheduling of jobs activities under different heat index conditions

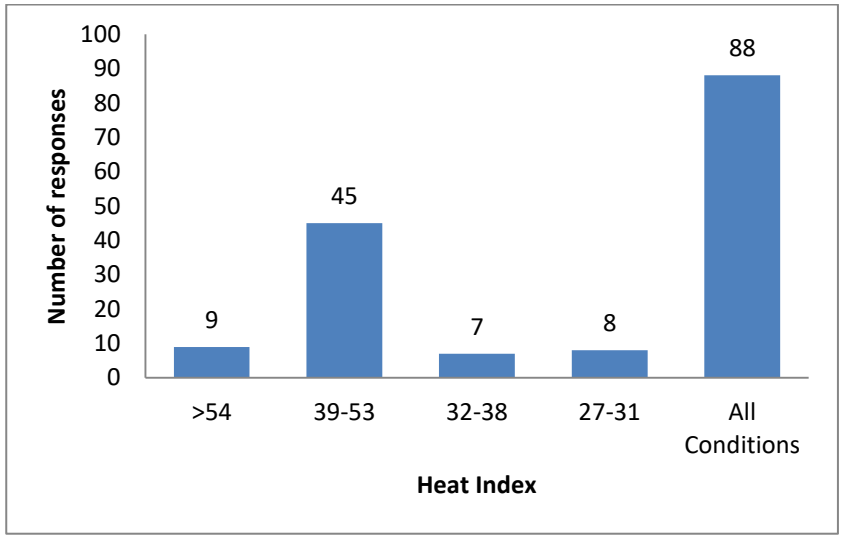

Figure 4-25: Number of responses for using glucose periodically under different heat index conditions

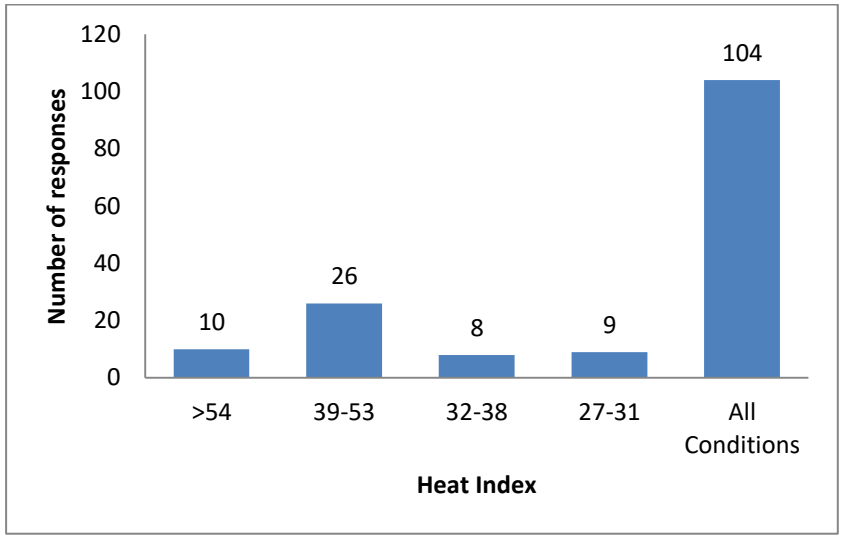

Figure 4-26: Number of responses for using flagging system under different heat index conditions

Provide temporary rest area with air conditioning and light objects under different Heat Index periods

Figure 4-27 and Figure 4-28 show the number of responses for using the administrative control methods provide temporary rest area and provide light objects under different heat index periods. The results show about 70 people per each method, prefer to use both methods for all types of weather. While others (around 65 responses) prefer to use both methods in the heat index period 39°C-53°C due to the severe effect of the heat on the workers' body.

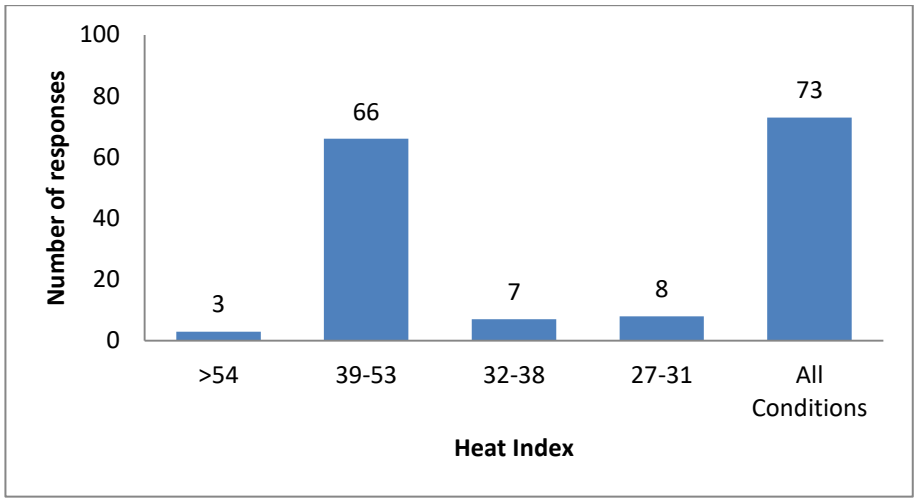

Figure 4-27: Number of responses for providing temporary rest area under different heat index conditions

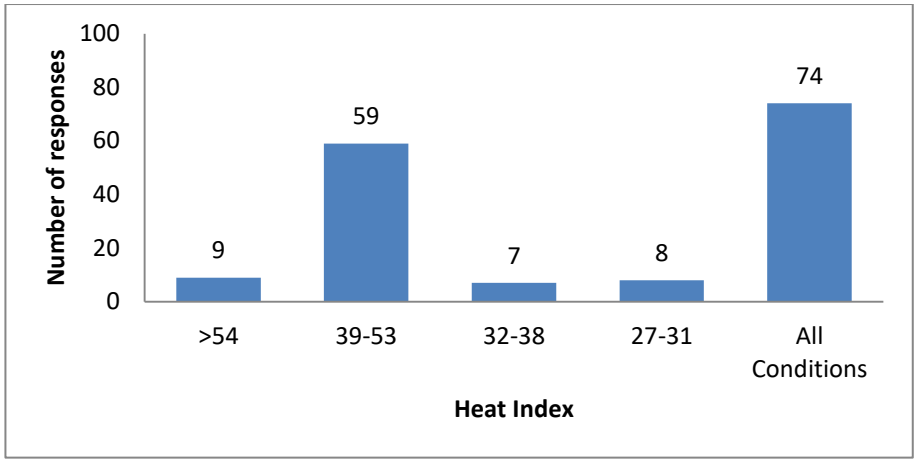

Figure 4-28: Number of responses for providing light obejects under different heat index conditions

Using sun cream protection under different heat index periods

Figure 4-29 shows the number of responses for using the control method sun cream under different heat index periods. The result shows that about 50% of the respondents (81 people) prefer to use sun cream for heat index period 39°C-53°C which meet the concept of using sun cream against sun. 49 people believe that we should use sun cream for all weather condition and others (less than 10 people per each heat index period) prefer to use sun cream for other heat index period >54°C, 32°C-38°C and 27°C-31°C.

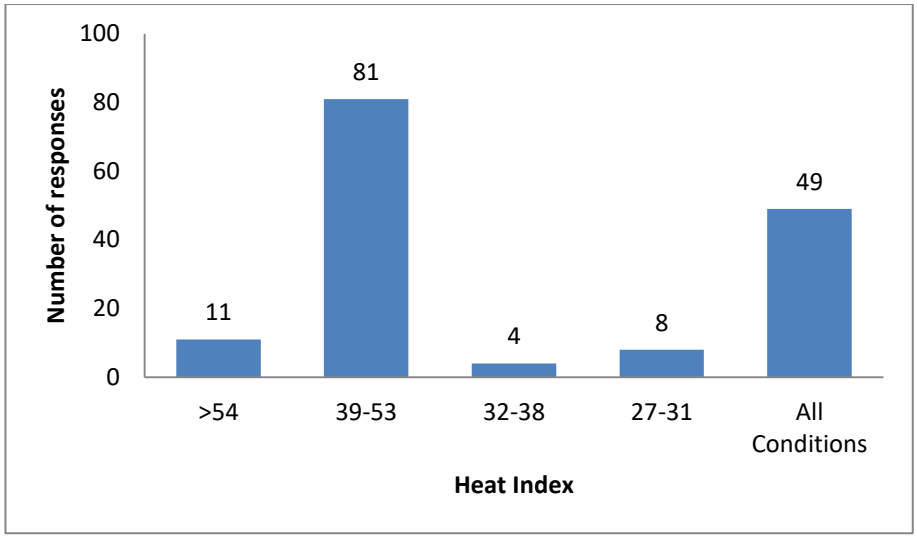

Figure 4-29: Number of responses for using sun cream under different heat index conditions

Prevent workers to drink hot drinks under different heat index periods

Figure 4-30 shows the number of responses for using the control method prevent worker to drink hot drinks under different heat index periods. The heat index periods all weather condition and 39°C-53°C are the most preferable for using this administrative method. This is because these people believe that hot drink should be prevented due to heat impact that results in increasing the body temperature. While others believe that hot drinks must not be prevent because their productivity will increase positively due to drinking hot drinks such as tea or coffee.

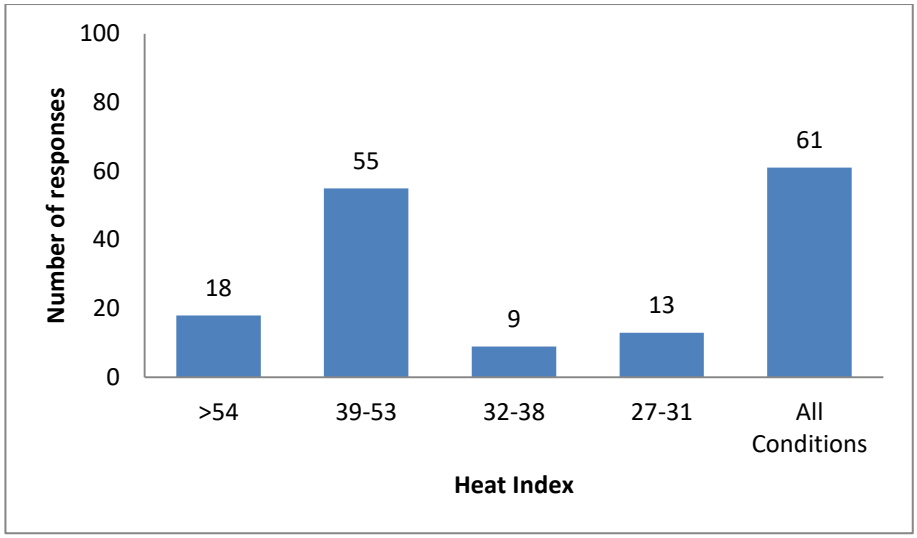

Figure 4-30: Number of responses for prevention of drinking hot drinks under different heat index conditions

Analysis of using [check the daily food of each labor, Provide heat stress preventative training, frequent labor department inspection and frequent HSE inspection] under different Heat Index periods

Figure 4-31, Figure 4-32, Figure 4-33, Figure 4-34 describe the condition of using the following administrative control methods under different heat index periods: check the daily food of each labor, provide heat stress preventative training, frequent labor department inspection and frequent HSE inspection. The results of these methods are closely similar with slight differences with the number of responses. We believe that these four control methods are matched with the results of the number of responses due to the major objective of using them which is follow-up the work safety progress and check the commitment toward the rules and regulations. Around 100 of the responses agreed to apply these regulations under all weather conditions, and this is connected to the opinion of must use follow-up rules to control heat stress in the

construction projects. About 20 responses believe in using these methods under the weather condition 39°C-53°C due to the severity of hot condition for working under this heat index period. While less than ten answers per each control method agreed to use these methods under the remaining heat index periods (>54°C, 32°C-38°C and 27°C-31°C) which gives us evidence to use these methods under all conditions.

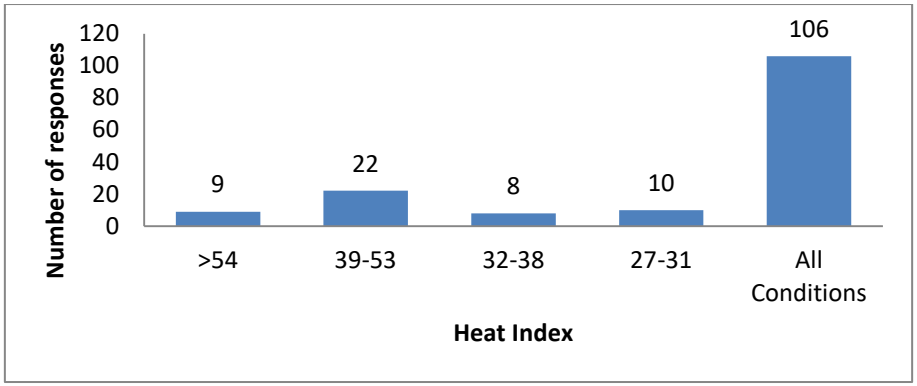

Figure 4-31: Number of responses for Check the laborer daily food under different heat index conditions

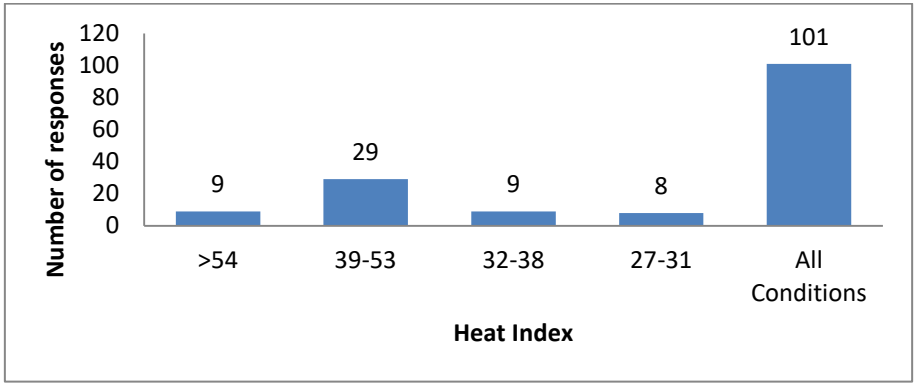

Figure 4-32: Number of responses for providing heat stress preventative training under different heat index conditions

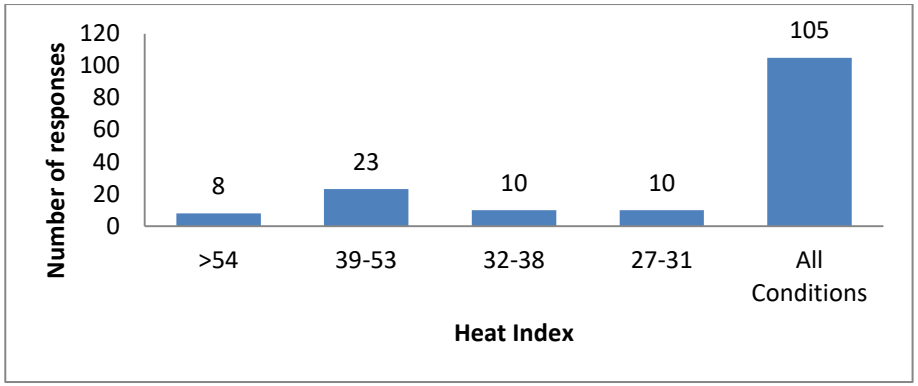

Figure 4-33: Number of responses for frequent Labor department inspection under different heat index conditions

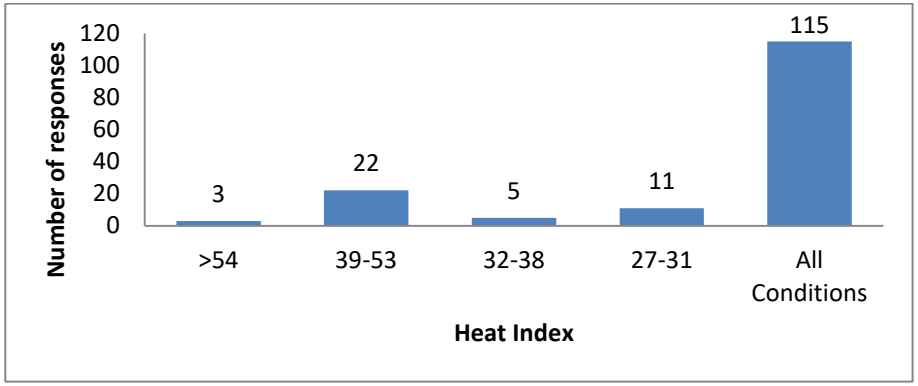

Figure 4-34: Number of responses for frequent internal HSE inspection under different heat index conditions

4.4.4 Part#3.7: Work Practice – Using Different Work-rest Rate under Different Heat Index per Different Work Rate Rotation

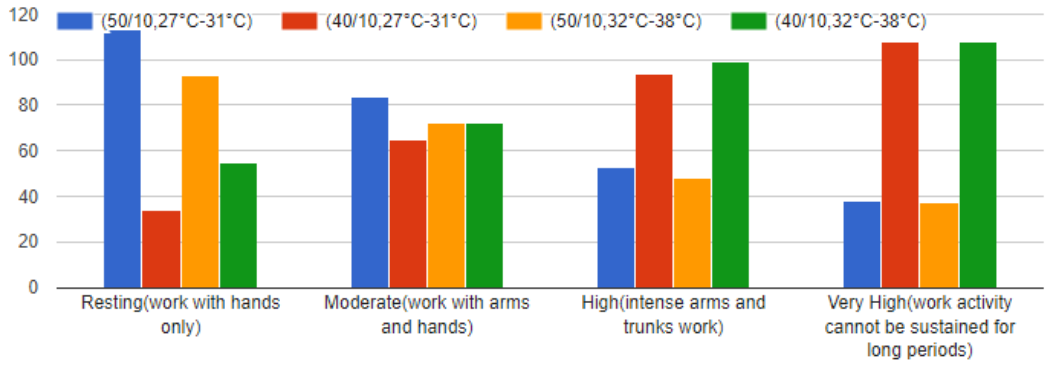

Figure 4-35: Number of responses for work/rest rotation rate under heat index periods 27°C-31°C and 32°C-38°C

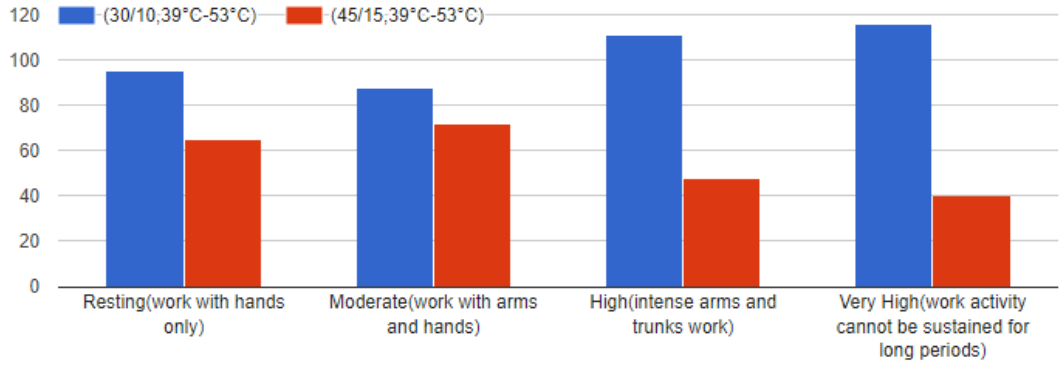

Figure 4-36: Number of responses for work/rest rotation rate under heat index period 39°C-53°C

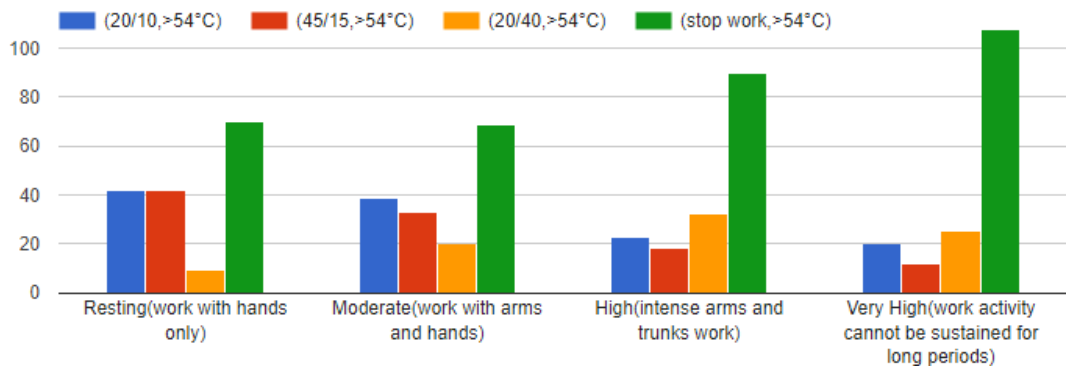

Figure 4-37: Number of responses for work/rest rotation rate under heat index >54 °C

In this part, the work/rest ratios are going to be investigated with different heat index periods to check which ratio is suitable and practical for use in the real physical work conditions where there are four work rate groups; resting (work with hands only), moderate (work with arms and hands), high (intense arms and trunks work), and very high (work activity cannot be sustained for long periods). The results are illustrated below:

Heat index (27°C – 31°C) & (32°C -38°C)

1. Resting (work with hands only):

Most of the respondents agreed to use the work/rest ratio 50/10 where 113 respondents agreed to use this ratio for the heat index 27°C-31°C and 93 respondents agreed to use this ratio for heat index 32°C-38°C. 33 of the respondents agreed to use the work/rest 40/10 ratio for the heat index 27°C-31°C and 55 of the respondents agreed to use this ratio for the heat index 32°C-38°C.

2. Moderate (work with arms and hands):

Here, the results are almost equal, the respondents agreed to use both the work/rest 50/10 or 40/10, where 84 person agreed to use the work/rest 50/10 for heat index (27°C-31°C) and 65 people agreed to use the work/rest 40/10 for the heat index period. Also, 72 people agreed to use the work/rest 50/10 or 40/10 for (32°C -38°C).

3. High (intense arms and trunks work):

The resonse context to this part was answered differently, compared with resting moderate rate work because people believe that once the rate of the work increases, the rest period should be more than the one who is working with less rate. About 90 people per each heat index perions agreed to use the work/rest 40/10 rate and about 50 people per each heat index believe that we should use the work/rest 50/10 ratio for both heat index.

4. Very high (work activity cannot be sustained for long periods)

The answers for this work rate are almost similar to the responses of high work rate, but the difference is that the rseponses increased for more than 100 responses to use the work/rest 40/10 for this type of work and decreased for less than 40 of repondents to use the work/rest 50/10.

5. To summarize the results of the previous 4 points, there is major agreement to use the work/rest ratio 50/10 for both heat indices under the work rate groups resting and moderate and 40/10 for both heat indices under the work rate groups high and very high. This is an indication that as long as the work rate is increased, so more rest the body should take.

Heat index (39°C-53°C)

1. Resting (work with hands only)

95 of the respondents agreed to use the work/rest 30/10 while 65 of the respondents agreed to use the work/rest 45/15.

2. Moderate (work with arms and hands):

88 of the respondents agreed to use the work/rest 30/10 while 72 of the respondents agreed to use the work/rest 45/15.

3. High (intense arms and trunks work):

111 of the respondents agreed to use the work/rest 30/10 while 48 of the respondents agreed to use the work/rest 45/15.

4. Very high (work activity cannot be sustained for long periods)

116 of the respondents agreed to use the work/rest 30/10 while 40 of the respondents agreed to use the work/rest 45/15.

5. To summarize the results of the previous 4 points, generally, there is significant agreement to use the 30/10 ratio with more assurance for high and very high work rate because the result show that the responses increased for the case of high and very high. Also, it is clear that there is a decrease for the work/rest 45/15 for the work rate high and very high. This is an indication that working 30 minutes and having a rest of 10 minutes is more preferable than working 40 minutes and having a rest of 15 minutes.

Heat index (>54 °C)

1. Resting (work with hands only)

42 of the respondents agreed to use the work/rest 20/10, 42 of the respondents agreed to use the work/rest 45/15, 9 of the respondents agreed to use the work/rest 20/40, 70 of the respondents agreed to use the work/rest stop work.

2. Moderate (work with arms and hands)

39 of the respondents agreed to use the work/rest 20/10, 33 of the respondents agreed to use the work/rest 45/15, 20 of the respondents agreed to use the work/rest 20/40, 69 of the respondents agreed to use the work/rest stop work.

3. High (intense arms and trunks work)

23 of the respondents agreed to use the work/rest 20/10, 18 of the respondents agreed to use the work/rest 45/15, 32 of the respondents agreed to use the work/rest 20/40, 90 of the respondents agreed to use the work/rest (stop work).

4. Very high (work activity cannot be sustained for long periods)

20 of the respondents agreed to use the work/rest (20/10), 12 of the respondents agreed to use the work/rest 45/15, 25 of the respondents agreed to use the work/rest 20/40, 108 of the respondents agreed to use the work/rest (stop work).

5. To summarize the results of the previous 4 points, there is major agreement to stop the work for the heat index period >54 °C. However, there is slight indication that when the work rate is resting or moderate, so we can use the work/rest 20/10 and 45/15. Also, there is indication that if the work could continuous when the heat index > 54, so it would be better to work 20 minutes and having a rest of 40 minutes for the work rate high and very high.

4.4.5 Part#3.8: Work Practice – Factors of Using Stoppage of Work Method

Table 4-7 shows that 63.1 % of the respondents so that " Heat Index more than 54" are the factors that should be considered in order to stop the work, 10.8% of the respondents so that " All of the above " are the factors that should be considered in order to stop the work.

Note: The meaning of “all of the above” indicate the answer toward the following factors; heat index more than 54, heat index less than 54, emergency case (people collapse), emergency case (fire) .

Table 4-7: Analysis of Question "What are the factors that should be considered in order to stop the work?"

	Frequency	Percentages
Any emergency case	5	3.2
Emergency Case (Fire)	11	7.0
Emergency Case (People Collapse)	11	7.0
Hear Index more than 54, emergency case	1	0.6
Heat Index less than 54	10	6.4
Heat index more than 45	1	0.6
Heat index more than 50	1	0.6
Heat Index more than 54	99	63.1
All of the above	17	10.8
All of the above except Heat Index less than 54	1	0.6
Total	157	100

Chapter5 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of this chapter is to present the result and the findings of the literature review, and questionnaire and conclude the overall work of the thesis with the research contribution and recommendations.

5.2 Conclusion

The main objective of this research is to identify administrative controls for management of heat stress that are used in the Qatari construction sector in order to effectively manage adverse side effect of heat exposure. We are fully aware of the importance of this research in supporting Qatar's strategy towards achieving the National Vision 2030, through which many vital institutions building have been constructed or still in progress, so the challenge comes here through how to manage the construction sector in Qatar. Administrative controls for heat stress are one of the approaches to manage and achieve the Qatari construction sector successfully because of the challenge of the nature of the climatic conditions in Qatar. We believe that this research can be useful to define the framework regulations of heat stress risks in the State of Qatar. The research methodology was based on the literature review and the research questionnaire. The purpose of the methodology approaches interpolates, makes clear answer and explicates the research question that is stated clearly about what are the different techniques that are used in the Qatari construction site in order

to manage and control heat stress.

Literature review part is about reviewing previous related research papers in GCC' countries, Hong Kong, United States of America and Australia, in order to find out the best theoretical administrative controls in different hot world regions, and in which the findings are practical approaches for Qatari construction projects. The results of the literature review method for these administrative controls are acclimatization, increasing the frequency and the length of breaks, scheduling of the work during the cooler times of the day and the year, making appropriate arrangements for hydration, allowing self-pacing of the work, providing adequate training to the workers by providing heat stress preventative training periodically, having sufficient ventilation and air conditioning system in place at the work site, detection of medical issues that could be related to heat stress, control the work cautiously for heat index period above 45 °C, and control the fluids that are consumed by the workers and the food as well.

The research questionnaire was distributed in the Qatari construction sites to find out the current practice management for heat stress. The targeting people of the research were Managers, Engineers, Foremen, and HSE Staff. Statistical analysis tests were applied for analyzing the questionnaire questions. The results of the research are illustrated, as follows:

- 50% of the sample population is from the age group 25-35, and the other half are for age's groups 20-25, 35-45, 45-55 and 56-60 where the lowest sample people are from the age's group 56-60 with 5% participant of the total.
- Work experience years in Qatar for the sample population are almost the same distribution for the groups' years 3-5, 5-7, 7-10, >10 where the group 5-7

years has the biggest distribution with 22% of the total size and the group 1-3 years has the lowest distribution with 17% of the total size.

- About one-third of the sample population worked in hot environment countries such as United Arab Emirates, Saudi Arabia, Oman, Egypt, Kuwait, Bahrain and Sudan. And, about 50% of the people worked in UAE.
- 55% of the sample size work 10 hour/day, while the 45% of sample size are distributed for the groups 8 hours/ day, 9 hours/day, 11 hours/day, more than or equal 12 hours/day where the lowest shift-work hours were from 9 hours/day.
- The results of outdoor work hours are that the maximum outdoor work hours are six hours with 30 people and the minimum hours are nine outdoor hours with one person.
- The overall weighted mean for the questionnaire part "Attitude toward work condition" is 76.82%, which indicates a high attitude of people toward the conditions of work.
- The overall weighted mean for the questionnaire part "Work Practice - performance conditions of working time "equals to 58.39%, which indicates that people are sometimes work in outdoor, near to hot source or close areas.
- The overall weighted mean for the part "Work practice - Conditions of wearing PPE - How often do you wear the PPE items" equals to 78.77%, which indicates that people often wear PPE.
- The overall weighted mean for the part "Work practice - How often the following issues are reported in job site?" equals to 52.55%, which indicates that the medical issues; muscle cramp, dizziness, thirsty, vomiting, fatigue,

sweating, heat rashes and syncope are rarely to be reported.

- The overall weighted mean for the part “Work-practice - The importance of the administrative control methods to control heat stress” equals to 80%, which indicates that people agree that the mentioned 23 administrative controls of this part are important. Also, the overall weighted mean for this part for groups Managers, Site workers, Engineers, Foremen, and HSE Staff are almost 80% for the important level of the administrative control methods for heat stress.
- There is slight agreement (about 30% to 40%) between the groups Foremen with HSE Staff, Engineers and Manager, which indicates that Foremen has a performance target with less safety performance, but HSE Staff, Managers and Engineers are always looking to safety target which most of the time control and limit the performance level.
- The consumed fluids in the Qatari construction sites are warm and/or cold water, oral hydration salt, glucose, tea and coffee. The most consumed fluid in the Qatari construction sites is warm and/or cold water (43% of the sample people) followed by water, glucose, and oral hydration salt with 16.6% of the sample size.
- 63% of the sample people suggested to stop the work when the heat index >54°C, and the remaining 37% of the sample people recommended to stop the work for different reasons such as heat index less than 54, emergency case (people collapse), emergency case (fire), heat index more than 45°C and 50 °C and any emergency case.

5.3 Contribution of the Current Research Study

This research has contributed to the academic field by:

- This research study is the first kind of study in Qatar, where we looked to the actual implementation of administrative controls on Job sites which has not been done in Qatar before.
- Agreement & Disagreement between the stakeholders of the construction sector in Qatar that have been done to examine the implementation of the administrative control method for heat stress issues.
- Examine the implementation of the following administrative control methods for heat stress:

1. Work stoppage
2. Frequent work break and Job rotation
3. Hydration (Provide unlimited potable drinkable water)
4. Provide calibrated temperature and humidity measuring instruments
5. Wearing fully enclosed clothes
6. Wearing light weight clothes
7. Wearing cotton clothes
8. Wearing cooling vest that have ice water for laborers
9. Using permeable PPE that allow sweating
10. Using fans for ventilation
11. Adequate acclimatization period
12. Provide temporary rest area with air conditioning

13. Provide mess hall

14. Provide light weight objects

15. Schedule hot jobs for the cooler part of the day or cooler part of the year

16. Using Flagging System

17. Using sun cream protection

18. Using glucose periodically

19. Prevent workers to drink hot drinks; tea, coffee...etc.

20. Check the daily food of each labor

21. Provide heat stress preventative training

22. Frequent Labor department inspection

23. Frequent internal HSE inspection

- Examine using the appropriate administrative controls for heat stress (27°C – 31°C), (32°C -38°C), (39°C – 53°C) and (>54°C).
- Examine using different work rest ratios under different workload types and different heat stress periods (27°C – 31°C), (32°C -38°C), (39°C – 53°C) and (>54°C).

5.4 Recommendations

The researcher would like to recommend the following recommendation as an overall output of this research.

Firstly, the following recommendations would be for Qatari Government:

- Qatari government should intensively follow-up the commitment of the companies for applying the safety regulations due to the major disagreement

of applying the administrative controls between the stakeholders of the construction sector.

- Qatari Government should reconsider to modify the existing law of stopping the work from June till September from 11:30am to 3:00pm. The proposed stoppage of work in the Qatari construction sites should be applied from 10am to 4pm for the period from June till September.
- Qatari Government should apply strictly that the work should be stopped once the heat index reach >54 °C and consider stopping the work for specific cases of work for the heat index period 39 °C - 53 °C .

Secondly, all construction institutions and companies should take into consideration the following recommendations:

- Because each individual company in the Qatari construction sector has own heat stress management plan, so all companies strictly should follow and apply the whole instructions and guidelines of MOPH heat stress management plan and MDLS
- Administrative staff (Manager, Engineers, and HSE Staff) should follow and monitor the laborers carefully in order to match the performance target with the safety precaution target.
- Due to the importance weight rank for the administrative control “Hydration”, Water (warm, and cold) should be provided continuously at the construction projects for the all the workers during the work time.
- The current case for stoppage of work should be reconsidered for modification because the heat index >54 °C is not the only sever case for heat stress.
- Due to the importance of the acclimatization, all companies should use

acclimatization as per the description of MOPH heat stress booklet, so All workers should be acclimatized to the heat level at the work site and to the workload levels for the initial period of the job (new, vacation, short leave).

- Buddy system was recommended by several literary sources such as (WCB, 2008) and MOPH heat stress Booklet, so work condition for the construction projects should be performed as a team work condition, so individual tasks for workers without check-in procedures should not be applied to perform the buddy system effectively.
- Due to the importance of ventilation for flowing the air and help cooling the body, so ventilation approach should be applied continuously for confined or closed zones (poor air flow).
- Cotton clothes should always be used during work time because they are useful in assisting the evaporation process by absorbing the body's sweat continuously.
- Scheduling of the activities must take into consideration the workload rate and the best time fitted to these activities.
- All construction companies should apply the medical program that is indicated by MOPH to identify early the symptoms of heat stress disorders and give immediate treatment.
- For heat index >54 °C, several administrative controls should be followed and the most important methods are work stoppage, wearing cooling vest that have ice water for laborers, Wearing light weight clothes, Prevent workers to drink hot drinks; tea, coffee..etc.
- For heat index 39°C-53°C, several administrative controls should be followed

and the most important methods are prevent workers to drink hot drinks; tea, coffee..etc., using permeable PPE that allow sweating, provide light objects, wearing light weight clothes, provide temporary rest area with air conditioning, wearing cooling vest that have ice water for laborers, frequent work break and Job rotation, using sun cream protection.

- For heat index (27°C – 31°C), several administrative controls should be followed and the most important methods are the whole 23 methods except work stoppage, frequent work break and Job rotation, schedule hot jobs for the cooler part of the day or cooler part of the year.
- For heat index (32°C-38°C), several administrative controls should be followed and the most important methods are the whole 23 methods except work stoppage, using sun cream protection, frequent internal HSE inspection, provide mess hall.
- For all heat index periods, several administrative controls should be followed and the most important methods are frequent internal HSE inspection, check the daily food of each labor, frequent Labor department inspection, using Flagging System, provide heat stress preventative training, hydration, schedule hot jobs for the cooler part of the day or cooler part of the year, acclimatization, wearing cotton light clothes, using glucose periodically, provide calibrated temperature and humidity measuring instruments, ventilation.

- For work/rest ratio regarding different workload and heat index period, the following table shows the recommended work/rest ratios for all construction companies:

Table 5-1: Recommended work/rest ratio

Work load rate	Heat Index			
	(27°C – 31°C)	(32°C-38°C)	(39°C-53°C)	(>54 °C)
Resting(work with hands only)	50/10	50/10	30/10	Stop work
Moderate(work with arms and hand)	50/10	40/10	30/10	Stop work
High(intense arms and trunks work)	40/10	40/10	30/10	Stop work
Very High(work activity cannot be sustained for long periods)	40/10	40/10	30/10	Stop work

5.5 Future Research

The researcher would like to point out some future research for the heat stress management in the State of Qatar:

- Scorecard heat stress management plan for Qatari construction sector.
- The future research should mearure the effect the heart rate when heat stress is greater than 45°C for all workers in the Qatari construction sector.

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APPENDICES

Appendix A: QUESTIONNAIRE FORM

Master Thesis Questionnaire

Qatar University

College Of Engineering

Engineering Management Master's Program

Dear Respected Participant

This questionnaire is intended to study the practice role of administrative controls for management of heat stress in construction sector in the State of Qatar. The results of this survey will be used for study purposes and shared with those who participated in filling out this survey. Information that you provide, is strictly confidential. Your participation is highly appreciated and makes this study success. We thank you for your consent of filling out this survey. By continuing this survey, you provide us the consent to use your opinion for the studies purposes.

The survey will take about 10-15 minutes for you to fill the questionnaire. Your participation is voluntary and you may withdraw at any time or skip any question

This research project and its procedures were reviewed and approved by Qatar University Review Board (QU-IRB Approval No. 805-E/17). If you have any questions please do not hesitate to contact us.

E-mail: aa1003198@qu.edu.qa , msiddiqui@qu.edu.qa Tel: +974 4403 4174

1. Select YES if you agree and proceed to the questionnaire; If you do not wish to participate, Select NO to exit *

Mark only one oval.

YES	◯
NO	◯

Part #1: Basic Personal Information

2. How old are you? *

Mark only one oval.

20 – 25 ◯ 26 - 35 ◯

36 - 45 ◯ 45 - 55 ◯

56 - 60 ◯

3. How many years have you worked in Qatar? *

Mark only one oval.

1 – 3 ◯ 3 - 5 ◯

5 – 7 ◯ 7 - 10 ◯

>10 ◯

4. Did you work in hot environment countries other than Qatar? *

Mark only one oval.

Yes ◯ No ◯

5. If the answer of the previous Question is Yes, Please specify these countries. Otherwise, go to the next Question.

……

……

6. Which of the following describes your current job occupation? *

Mark only one oval.

Project Manager	◯	HSE Staff	◯
Construction Manager	◯	Project Engineer	◯
Site Engineer	◯	Foreman	◯
Other:	◯	_____	

7. What is the average shift-work time duration (hour / day)? *

Mark only one oval.

8 ◯ 9 ◯ 10 ◯ 11 ◯ >12 ◯

8. How many hours per day in Question 7 do you spend outdoor? *

…….

Part#2: Attitude toward work condition

We would like to ask you about your attitude toward work condition? Please indicate whether you strongly agree, agree, neither agree nor disagree, disagree or strongly disagree with each of the questions below. Please click on one answer per question Mark only one answer per row.

	Strongly agree	agree	Neutral	Disagree	Strongly disagree
1. In your opinion, are the existing work rules have enough provisions in order to control heat stress?					
2. Do you think the laborers should work in a proper weather condition?					
3. Do you think that there is violation in work role under heat in Qatar?					

Part#3.1: Work Practice – frequency of wearing items

Mark only one answer per row.

How often do you wear the following items?					
Items	Always	Often	Sometimes	Rarely	Never
1. Safety goggle					
2. Pants					
3. T-shirt					
4. Long sleeve					
5. Helmet					
6. Safety Vest					
7. Safety shoes					
8. Coveralls (cotton)					
Do you ask laborers to wear one or more of the items described in previous Question?					

Part#3.2: Work practice – performance conditions of working time

Mark only one answer per row.

How often do you work under the following conditions?					
Items	Always	Often	Sometimes	Rarely	Never
1. How much time do you spend in outdoor working zones?					
2. How much time do you spend working near to hot machinery(generator, equipment vehicles, welding machine)					
3. How much time do you spend working in confined or closed areas?					

Part#3.3: "Work practice - How often the following issues are reported in job site"

Mark only one answer per row.

How often the following issues are reported in your job site?					
Items	Always	Often	Sometimes	Rarely	Never
1. Muscle cramp					
2. Dizziness					
3. Thirsty					
4. Vomiting					
5. Fatigue					
6. Sweating					
7. Heat rashes					
8. Syncope					

Part#3.4: Work Practice –the most fluids consumed during work time

What are the most fluids consumed during the work time?

Mark only one oval.

Warm and/or Cold Water ◯ Oral hydration salt ◯

Glucose ◯ Tea and Coffee, Water ◯

Lemon juice ◯ Soft Drinks ◯

Soft Drinks ◯ Other: _____

Part#3.5: "Work practice - Importance level of the administrative control methods to control heat stress"

Mark only one answer per row.

How important are the following administrative control methods to control heat stress?					
Items	Very Important	Important	Moderately Important	Slightly Important	Not Important
1. Work stoppage					
2. Frequent work break and Job rotation					
3. Hydration (Provide unlimited potable drinkable water)					
4. Provide calibrated temperature and humidity measuring instruments					
5. Wearing fully enclosed clothes					
6. Wearing light weight clothes					
7. Wearing cotton clothes					
8. Wearing cooling					

vest that have ice water for laborers					
9. Using permeable PPE that allow sweating					
10. Using fans for ventilation					
11. Adequate acclimatization period					
12. Provide temporary rest area with air conditioning					
13. Provide mess hall					
14. Provide light weight objects					
15. Schedule hot jobs for the cooler part of the day or cooler part of the year					
16. Using Flagging System					
17. Using sun cream protection					
18. Using glucose periodically					
19. Prevent workers to drink hot drinks; tea,					

coffee...etc.					
20. Check the daily food of each labor					
21. Provide heat stress preventative training					
22. Frequent Labor department inspection					
23. Frequent internal HSE inspection					

Part#3.6: Work Practice – Using different administrative control methods under different heat index condition

Mark only one answer per row.

Under what conditions of Heat Index do you use the following administrative control methods? **Note: Heat Index is a combination of air temperature and relative humidity**					
Items	27°C-31°C	32°C-38°C	39°C-53°C	>54 °C	All Conditions
1. Work stoppage					
2. Frequent work break and Job rotation					
3. Hydration (Provide unlimited potable drinkable water)					

4. Provide calibrated temperature and humidity measuring instruments					
5. Wearing fully enclosed clothes					
6. Wearing light weight clothes					
7. Wearing cotton clothes					
8. Wearing cooling vest that have ice water for laborers					
9. Using permeable PPE that allow sweating					
10. Using fans for ventilation					
11. Adequate acclimatization period					
12. Provide temporary rest area with air conditioning					
13. Provide mess hall					
14. Provide light weight objects					
15. Schedule hot jobs for the cooler part of the day or cooler part of the year					
16. Using Flagging System					
17. Using sun cream protection					
18. Using glucose					

periodically					
19. Prevent workers to drink hot drinks; tea, coffee…etc.					
20. Check the daily food of each labor					
21. Provide heat stress preventative training					
22. Frequent Labor department inspection					
23. Frequent internal HSE inspection					

Part#3.7: Work Practice – Using different work-rest rotation under different heat index per different work rate rotation

Check all that apply.

What is the appropriate work rest rate with specific heat index (Work/rest, heat index) for the following categories of work rates?				
	Heat Index : (27°C-31°C)		Heat Index : (32°C-38°C)	
	50work/10rest	40work/10rest	50work/10rest	40work/ 10rest
Resting(work with hands only)				
Moderate(work with arms and hands)				

High(intense arms and trunks work)				
Very High(work activity cannot be sustained for long periods)				

Heat Index : (39°C-53°C)

	30work/10rest	45work/15rest
Resting(work with hands only)		
Moderate(work with arms and hands)		
High(intense arms and trunks work)		
Very High(work activity cannot be sustained for long periods)		

Heat Index : (>54 °C°C)

	20 work /10rest	45work /15rest	20work /40rest	stop work,>54 °C
Resting(work with hands only)				

Moderate(work with arms and hands)				
High(intense arms and trunks work)				
Very High(work activity cannot be sustained for long periods)				

Part#3.8: Work Practice – Factors of using stoppage of work method

What are the factors that should be considered in order to stop the work?

Mark only one oval.

Heat Index more than 54 ◯ Heat Index less than 54 ◯

Emergency Case (People Collapse) ◯ Emergency Case (Fire) ◯

Other: ◯ _____

Part#3.9: Work Practice – Suggestions for improvement

What suggestions do you have so that we meet the best administrative control of heat stress in construction sites?

……

……

……

……

Appendix B: RESEARCH ETHICS APPROVAL FORM

جامعة قطر
QATAR UNIVERSITY

Qatar University Institutional Review Board
QU-IRB

July 20, 2017

Mr. Ahmed Y.M. Alaila
CENG Graduate Student Project
College of Engineering
Qatar University
Tel.: 66516583
Email: aa1003198@qu.edu.qa

Dear Mr. Ahmed Alaila,

Sub.: **Research Ethics Review Exemption / CENG Graduate Student Project**
Ref.: **Project titled, "Administrative controls for management of heat stress on Qatari construction sites"**

We would like to inform you that your application along with the supporting documents provided for the above proposal, is reviewed and having met all the requirements, has been exempted from the full ethics review.

Please note that any changes/modification or additions to the original submitted protocol should be reported to the committee to seek approval prior to continuation.

Your Research Ethics Approval No. is: **QU-IRB 805-E/17**

Kindly refer to this number in all your future correspondence pertaining to this project.

Best wishes,

K. Alali

Dr. Khalid Al-Ali
Chairperson, QU-IRB

Institutional Review Board
(IRB)
Office Of Academic Research

Appendix C: DETAIL TABLES

Table C- 1: The correlation coefficient between each question per each part in the questionnaire

Fields	Spearman coefficient	p-value
Attitude toward work condition		
1. In your opinion, are the existing work rules have enough provisions in order to control heat stress?	0.362	0.000
2. Do you think the laborers should work in a proper weather condition?	0.565	0.000
3. Do you think that there is violation in work role under heat in Qatar?	0.620	0.000
Work Practice – Performance conditions of working time	Spearman coefficient	p-value
1. How much time do you spend in outdoor working zones?	0.534	0.000
2. How much time do you spend working near to hot machinery (generator, equipment vehicles, welding machine)?	0.828	0.001
3. How much time do you spend working in confined or closed areas?	0.686	0.000
Work Practice - importance level of the administrative control methods to control heat stress	Spearman coefficient	p-value
1. Work stoppage	0.455	0.000
2. Frequent work break and Job rotation	0.578	0.000
3. Hydration (Provide unlimited potable drinkable water)	0.638	0.000
4. Provide calibrated temperature and humidity measuring instruments	0.534	0.000
5. Wearing fully enclosed clothes	0.349	0.000
6. Wearing light weight clothes	0.420	0.000
7. Wearing cotton clothes	0.540	0.000
8. Wearing cooling vest that have ice water for laborers	0.408	0.000

9. Using permeable PPE that allow sweating	0.542	0.000
10. Using fans for ventilation	0.584	0.000
11. Adequate acclimatization period	0.552	0.000
12. Provide temporary rest area with air conditioning	0.465	0.000
13. Provide mess hall	0.656	0.000
14. Provide light weight objects	0.565	0.000
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	0.564	0.000
16. Using Flagging System	0.614	0.000
17. Using sun cream protection	0.307	0.000
18. Using glucose periodically	0.545	0.000
19. Prevent workers to drink hot drinks; tea, coffee... etc.	0.300	0.000
20. Check the daily food of each labor	0.506	0.000
21. Provide heat stress preventative training	0.617	0.000
22. Frequent Labor department inspection	0.518	0.000
23. Frequent internal HSE inspection	0.562	0.000
	Spearman	p-value
Work practice - Conditions of wearing PPE	coefficient	
1. Safety goggle	0.777	0.000
2. Pants	0.434	0.000
3. T-shirt	0.375	0.000
4. Long sleeve	0.576	0.000
5. Helmet	0.624	0.000
6. Safety Vest	0.634	0.000
7. Safety shoes	0.479	0.000
8. Coveralls	0.227	0.004
Work practice - How often the following issues are reported in job site"	Spearman coefficient	p-value
1. Muscle cramp	0.608	0.000
2. Dizziness	0.669	0.000
3. Thirsty	0.391	0.000

4. Vomiting	0.665	0.000
5. Fatigue	0.561	0.000
6. Sweating	0.482	0.000
7. Heat rashes	0.587	0.000
8. Syncope	0.577	0.000

Table C- 2: Research hypothesis for question "How often do you wear the following items"

Question	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Safety goggle	3.47	69.43	1.53	3.86	0.00	7
2. Pants	4.61	92.23	0.89	22.71	0.00	2
3. T-shirt	4.25	85.10	1.16	13.56	0.00	5
4. Long sleeve	3.82	76.43	1.28	8.05	0.00	6
5. Helmet	4.48	89.68	0.89	20.92	0.00	3
6. Safety Vest	4.45	88.92	0.94	19.35	0.00	4
7. Safety shoes	4.69	93.76	0.74	28.53	0.00	1
8. Coveralls (cotton)	1.73	34.65	1.33	-11.92	0.00	8
Total	3.94	78.77	1.53	19.45	0.00	

Table C- 3: Research hypothesis for the question " How often the following issues are reported in job site "

Question	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Muscle cramp	2.04	40.76	1.08	-11.16	.000	5
2. Dizziness	2.29	45.73	1.19	-7.49	.000	4
3. Thirsty	3.97	79.49	1.13	10.79	.000	2
4. Vomiting	2.00	40.00	1.06	-11.80	.000	6
5. Fatigue	2.84	56.82	1.33	-1.50	.136	3
6. Sweating	4.17	83.44	1.17	12.59	.000	1
7. Heat rashes	1.92	38.47	1.10	-12.25	.000	7
8. Syncope	1.78	35.67	1.06	-14.41	.000	8
Total	2.63	52.55	.73	-6.40	.000	

Table C- 4: Research hypothesis for the important of the administrative control methods to control heat stress – Group#2

Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Work stoppage	4.06	81.29	0.96	6.15	0.00	16
2. Frequent work break and Job rotation	4.16	83.23	0.90	7.20	0.00	12
3. Hydration (Provide unlimited potable drinkable water)	4.55	90.97	0.68	12.77	0.00	1
4. Provide calibrated temperature and humidity measuring instruments	4.16	83.23	1.00	6.45	0.00	13
5. Wearing fully enclosed clothes	3.23	64.52	1.28	0.98	0.34	21
6. Wearing light weight clothes	3.58	71.61	1.31	2.47	0.02	19
7. Wearing cotton clothes	4.16	83.23	1.07	6.06	0.00	14
8. Wearing cooling vest that have ice water for laborers	3.35	67.10	1.36	1.46	0.16	20
9. Using permeable PPE that allow sweating	4.10	81.94	1.11	5.52	0.00	15
10. Using fans for ventilation	4.19	83.87	1.01	6.55	0.00	9
11. Adequate acclimatization period	4.32	86.45	1.01	7.27	0.00	3
12. Provide temporary rest area with air conditioning	4.16	83.23	0.78	8.30	0.00	11
13. Provide mess hall	4.23	84.52	0.72	9.52	0.00	7
14. Provide light weight objects	4.00	80.00	0.86	6.50	0.00	17
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	4.35	87.10	0.91	8.25	0.00	2
16. Using Flagging System	4.32	86.45	1.14	6.48	0.00	4
17. Using sun cream protection	2.97	59.35	1.52	-0.12	0.91	23
18. Using glucose periodically	4.19	83.87	0.98	6.78	0.00	10

19. Prevent workers to drink hot drinks; tea, coffee…etc.	3.03	60.65	1.30	0.14	0.89	22
20. Check the daily food of each labor	3.61	72.26	1.20	2.84	0.01	18
21. Provide heat stress preventative training	4.29	85.81	0.78	9.18	0.00	5
22. Frequent Labor department inspection	4.26	85.16	0.96	7.26	0.00	6
23. Frequent internal HSE inspection	4.23	84.67	1.09	6.32	0.00	8
Total	3.98	79.59	0.54	10.19	0.00	

Table C- 5: Research hypothesis for the important of the administrative control methods to control heat stress – Group#3

Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Work stoppage	3.98	79.52	1.05	10.39	0.00	16
2. Frequent work break and Job rotation	4.04	80.80	1.02	11.41	0.00	13
3. Hydration (Provide unlimited potable drinkable water)	4.46	89.21	0.79	20.84	0.00	1
4. Provide calibrated temperature and humidity measuring instruments	4.01	80.16	0.98	11.50	0.00	15
5. Wearing fully enclosed clothes	3.59	71.75	1.11	5.93	0.00	20
6. Wearing light weight clothes	3.77	75.40	1.04	8.27	0.00	18
7. Wearing cotton clothes	4.28	85.60	0.83	17.40	0.00	4
8. Wearing cooling vest that have ice water for laborers	3.63	72.70	1.24	5.76	0.00	19
9. Using permeable PPE that allow sweating	4.02	80.32	0.99	11.54	0.00	14
10. Using fans for ventilation	4.39	87.78	0.84	18.59	0.00	2
11. Adequate acclimatization period	4.14	82.74	0.99	12.88	0.00	11
12. Provide temporary rest area with air conditioning	4.18	83.65	0.88	15.08	0.00	9
13. Provide mess hall	4.19	83.81	0.90	14.83	0.00	8
14. Provide light weight objects	3.94	78.88	0.93	11.37	0.00	17
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	4.23	84.60	0.98	14.07	0.00	6
16. Using Flagging System	4.31	86.19	1.00	14.70	0.00	3
17. Using sun cream protection	3.24	64.76	1.26	2.12	0.04	23
18. Using glucose periodically	4.15	83.02	0.90	14.29	0.00	10

19. Prevent workers to drink hot drinks; tea, coffee…etc.	3.44	68.80	1.18	4.18	0.00	22
20. Check the daily food of each labor	3.52	70.32	1.12	5.16	0.00	21
21. Provide heat stress preventative training	4.21	84.16	0.85	15.93	0.00	7
22. Frequent Labor department inspection	4.14	82.86	0.91	14.10	0.00	12
23. Frequent internal HSE inspection	4.27	85.41	0.90	15.78	0.00	5
Total	4.01	80.11	0.46	24.35	0.00	

Table C- 6: Research hypothesis for the important of the administrative control methods to control heat stress – Group#4

Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Work stoppage	4.12	82.33	0.98	8.86	0.00	9
2. Frequent work break and Job rotation	4.15	83.05	0.86	10.38	0.00	6
3. Hydration (Provide unlimited potable drinkable water)	4.45	89.00	0.77	14.61	0.00	1
4. Provide calibrated temperature and humidity measuring instruments	3.88	77.67	1.03	6.66	0.00	16
5. Wearing fully enclosed clothes	3.65	73.00	1.12	4.51	0.00	18
6. Wearing light weight clothes	3.60	72.00	1.09	4.25	0.00	19
7. Wearing cotton clothes	4.19	83.73	0.83	11.03	0.00	4
8. Wearing cooling vest that have ice water for laborers	3.60	72.00	1.29	3.60	0.00	20
9. Using permeable PPE that allow sweating	3.95	79.00	0.91	8.09	0.00	13
10. Using fans for ventilation	4.32	86.33	0.83	12.24	0.00	2
11. Adequate acclimatization period	3.91	78.28	1.12	6.30	0.00	15
12. Provide temporary rest area with air conditioning	4.08	81.67	0.93	9.06	0.00	10
13. Provide mess hall	4.07	81.33	0.94	8.82	0.00	11
14. Provide light weight objects	3.80	75.93	0.97	6.36	0.00	17
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	4.03	80.67	1.06	7.57	0.00	12
16. Using Flagging System	4.15	83.00	1.09	8.20	0.00	7
17. Using sun cream protection	3.02	60.33	1.24	0.10	0.92	23
18. Using glucose periodically	3.92	78.33	0.96	7.38	0.00	14

19. Prevent workers to drink hot drinks; tea, coffee…etc.	3.35	67.00	1.15	2.36	0.02	22
20. Check the daily food of each labor	3.42	68.33	1.11	2.91	0.01	21
21. Provide heat stress preventative training	4.19	83.73	0.83	11.03	0.00	5
22. Frequent Labor department inspection	4.13	82.67	0.89	9.84	0.00	8
23. Frequent internal HSE inspection	4.21	84.14	0.95	9.82	0.00	3
Total	3.92	78.41	0.48	14.83	0.00	

Table C- 7: Research hypothesis for the important of the administrative control methods to control heat stress – Group#5

Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Work stoppage	3.55	70.97	1.26	2.42	0.02	20
2. Frequent work break and Job rotation	3.39	67.74	1.20	1.79	0.08	21
3. Hydration (Provide unlimited potable drinkable water)	4.23	84.52	0.92	7.41	0.00	8
4. Provide calibrated temperature and humidity measuring instruments	3.87	77.42	1.09	4.46	0.00	16
5. Wearing fully enclosed clothes	3.71	74.19	1.10	3.59	0.00	18
6. Wearing light weight clothes	4.13	82.58	0.99	6.34	0.00	10
7. Wearing cotton clothes	4.39	87.74	0.92	8.40	0.00	1
8. Wearing cooling vest that have ice water for laborers	3.97	79.35	1.30	4.13	0.00	15
9. Using permeable PPE that allow sweating	4.35	87.10	0.88	8.60	0.00	2
10. Using fans for ventilation	4.29	85.81	0.97	7.39	0.00	5
11. Adequate acclimatization period	4.29	85.81	0.90	7.97	0.00	6
12. Provide temporary rest area with air conditioning	4.06	81.29	0.89	6.64	0.00	12
13. Provide mess hall	4.23	84.52	0.84	8.08	0.00	9
14. Provide light weight objects	3.87	77.42	1.06	4.59	0.00	17
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	4.35	87.10	0.84	9.00	0.00	3
16. Using Flagging System	4.26	85.16	1.12	6.23	0.00	7
17. Using sun cream protection	3.29	65.81	1.60	1.01	0.32	23
18. Using glucose periodically	4.32	86.45	0.91	8.10	0.00	4

19. Prevent workers to drink hot drinks; tea, coffee…etc.	3.35	67.10	1.40	1.41	0.17	22
20. Check the daily food of each labor	3.61	72.26	1.33	2.56	0.02	19
21. Provide heat stress preventative training	4.00	80.00	0.93	5.98	0.00	14
22. Frequent Labor department inspection	4.03	80.65	0.95	6.06	0.00	13
23. Frequent internal HSE inspection	4.10	82.00	0.94	6.49	0.00	11
Total	3.98	79.69	0.51	10.78	0.00	

Table C- 8: Research hypothesis for the important of the administrative control methods to control heat stress – Group#6

Administrative Control(AC)	Mean value	Weight Mean	standard deviation	t-test value	P-value	Ranking order
1. Work stoppage	4.11	82.29	0.90	7.32	0.00	16
2. Frequent work break and Job rotation	4.43	88.57	0.85	9.94	0.00	7
3. Hydration (Provide unlimited potable drinkable water)	4.69	93.71	0.63	15.80	0.00	1
4. Provide calibrated temperature and humidity measuring instruments	4.34	86.86	0.73	10.95	0.00	12
5. Wearing fully enclosed clothes	3.37	67.43	1.11	1.97	0.03	23
6. Wearing light weight clothes	3.74	74.86	0.95	4.63	0.00	18
7. Wearing cotton clothes	4.34	86.86	0.73	10.95	0.00	13
8. Wearing cooling vest that have ice water for laborers	3.40	68.00	1.03	2.29	0.03	22
9. Using permeable PPE that allow sweating	3.83	76.57	1.15	4.26	0.00	17
10. Using fans for ventilation	4.60	92.00	0.69	13.63	0.00	3
11. Adequate acclimatization period	4.37	87.43	0.73	11.10	0.00	10
12. Provide temporary rest area with air conditioning	4.46	89.14	0.74	11.63	0.00	5
13. Provide mess hall	4.37	87.43	0.88	9.25	0.00	11
14. Provide light weight objects	4.26	85.14	0.66	11.32	0.00	14
15. Schedule hot jobs for the cooler part of the day or cooler part of the year	4.46	89.14	0.92	9.39	0.00	6
16. Using Flagging System	4.63	92.57	0.60	16.10	0.00	2
17. Using sun cream protection	3.57	71.43	0.85	3.98	0.00	21
18. Using glucose periodically	4.40	88.00	0.69	11.93	0.00	9

19. Prevent workers to drink hot drinks; tea, coffee…etc.	3.68	73.53	1.02	3.92	0.00	19
20. Check the daily food of each labor	3.60	72.00	0.95	3.75	0.00	20
21. Provide heat stress preventative training	4.43	88.57	0.78	10.87	0.00	8
22. Frequent Labor department inspection	4.26	85.14	0.92	8.10	0.00	15
23. Frequent internal HSE inspection	4.53	90.59	0.74	12.28	0.00	4
Total	4.17	83.36	0.35	19.93	0.00	