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Contribution of Open-air Concrete Slabs to the Heat Stress on Working Man

Alex A. Marcelo*, Lucila C. Labaki, Adriana E. B. Amorim

Abstract
The objective of this work was to evaluate the heat stress on workers of the construction industry on open-air concrete slabs in the city of Campinas, São Paulo, Brazil. Brazilian NR-15 provides a method for evaluating the heat stress to which a person is exposed using the WBGT (wet bulb globe temperature) index, prescribing rest pauses according to the type of activity. The methodology included measurements of environmental thermal variables and atmospheric quantities, followed by the calculation of the WBGT index. Data was collected at 12 different locations from August/2017 to March/2018, covering three diferent seasons. Results show that moderate and heavy activities on concrete slabs require pauses in every month, except in August.

Key words:
heat stress, thermal comfort, construction industry

Introduction

Workers of the construction industry often need to wear clothing and protective equipment covering most of their bodies. Such clothing conditions, added to the work rate and the working climate[1], may lead to heat stress, which occurs when the body's means of controlling its internal temperature starts to fail. Among the several effects of heat stress, typical symptoms are an inability to concentrate, muscle cramps, fainting, heat exhaustion, and heat stroke. The heat stress to which a person is exposed may be evaluated by the WBGT index. With two QUESTemp°™ 36 (3M™) data loggers, real-time readings for wet-bulb (Tbn), dry-bulb (Tbs) and globe (Tg) temperatures were performed simultaneously on two different surfaces (grass and concrete) from August/2017 to March/2018 between 9:00 and 16:00. Albedo calculations were performed from measurements by a CNR1 Net Radiometer (Campbell Scientific). For locations with solar load, NR-15[2] establishes that the WBGT index be determined by the equation WBGT = 0.7 Tbn + 0.2 Tg + 0.1 Tbs.

Results and Discussion

Results for December are shown in Image 1. During this month, the WBGT index on the concrete slab is higher than the one on the reference grass surface. This can be explained by the heat exchanges between the surface and the environment, and by the radiant heat flux from the surface. The average albedo on concrete slabs is 0.30. Rest pauses expected for moderate and heavy activities on concrete slabs are shown in Chart 1.

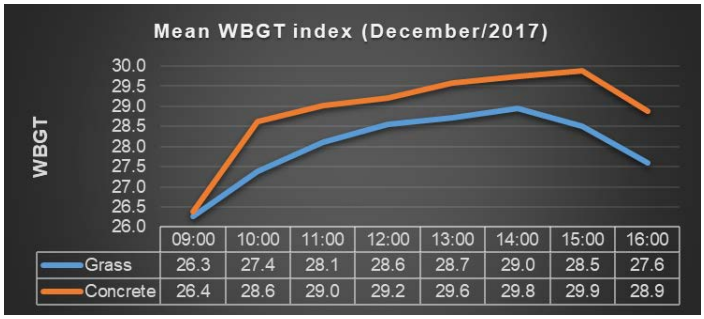

Image 1. Mean WBGT index in December/2017

Chart 1. Rest pauses at work on concrete slabs, in min.

Period	Activity	Month							
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
9:00-10:00	Moderate					30			
	Heavy			15	30	45			30
10:00-11:00	Moderate				15	30		15	15
	Heavy			30	30	45		30	45
11:00-12:00	Moderate				15	30	15	30	30
	Heavy		30	30	30	45	30	45	45
12:00-13:00	Moderate		15		15	45	15	30	30
	Heavy		30	30	30	45	30	45	45
13:00-14:00	Moderate			15	15	45	15	15	60
	Heavy		30	30	30	45	45	45	60
14:00-15:00	Moderate			15	15	45		30	45
	Heavy		30	45	30	45	30	45	45
15:00-16:00	Moderate			15	15	30		30	45
	Heavy		30	30	30	45		45	60

Conclusions

Results show that light activities require no pause at all, except in March, when the highest temperatures were recorded. Moderate and heavy activities require pauses in every month, except in August (Winter). Ongoing studies suggest that a significant fraction of heat received during work on a concrete slab is related to the emission of infrared radiation and convection. In fact, data from a Ti110 Infrared Camera (Fluke) shows that concrete has an average surface temperature 4.5° C higher than grass.

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[1] International Organization for Standardization. **ISO 7226** – Ergonomics of the thermal environment – Assessment of heat stress using the WBGT (wet bulb globe temperature) index. Genebra, Suiça, 2017.

[2] BRASIL. Ministério do Trabalho e Emprego. **NR 15** – Atividades e Operações Insalubres. Brasília, DF, 1978. Disponível em: <http://trabalho.gov.br/images/Documentos/SST/NR/NR15/NR15-ANEXO3.pdf>. Acesso em: 13 jul. 2018.