

**ENGINEERING FACTORS TO DEVELOP
A SUSTAINABLE ENVIRONMENTAL
CONTROL SYSTEM FOR RABBIT
PRODUCTION**

By

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B. Sc. Agric. Sc. (Agric. Engineering), Ain Shams University, 2008

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ABSTRACT

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This research aims to study the effect of using Modified Trombe-Wall (MTW) in natural ventilation system to decrease thermal load in rabbit house. A Modified Trombe-Wall is a south-facing concrete blackened wall and covered on the exterior by glazing. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from irradiating to the outside. The experimental model was set up at Shoubra El-Kheima, Egypt. Results of the experimental work show that the (MTW) actually decreases temperature inside the model by seven-degrees Celsius. The technique achieved the largest ventilation rate ($0.014 \text{ m}^3/\text{s}$) at time 2 pm (September).

The results of theoretical Study for Trombe Wall system at rabbit house indicated that ventilation with TW decrease the heat stress by average thermal efficiency 20.7 %. The system of natural ventilation causing possible absence of stress conditions was detected ($\text{THI} < 27.8$).

Keywords: Trombe Wall, Comfort zone, Ventilation, Animal environment

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LIST OF ABBREVIATIONS

Abbreviation	Definition	Page No.
T_i	inside air temperatures.-----	25
T_o	outside air temperatures.-----	25
T_r	Room temperature.-----	25
T_s	The temperature on the surface of the south wall.-----	25
T_g	temperature of the air gap.-----	25
V_i	inside air velocity.-----	25
V_o	outside air velocity.-----	25
T_m	ambient air temperature.-----	25
V_m	ambient air velocity.-----	25
Q	The rate of heat transfer.-----	31
\dot{m}	Mass flow rate.-----	31
c_p	Specific heat of air.-----	31
T_{in}	input air temperature to chimney.-----	31
T_{out}	output air temperature from chimney.-----	32
U	The overall heat transfer coefficient.-----	32
A_s	The surface area.-----	32
q	The rate of heat transfer per unit area.-----	32
ρ	density of air.-----	32
\dot{V}	flow rate.-----	32
A_o	the area of air outlet.-----	32
v_o	exit air velocity.-----	32
AR	Air exchange rate per hour.-----	32
V	air volume in model.-----	32
SHP	The rate of sensible heat production.-----	33
T_a	Ambient air temperature of house.-----	33
q_s	Sensible heat gain from the rabbits.-----	33
W	Weight of rabbit.-----	33

n	Number of rabbits.-----	33
q_f	Heat flow through building floor.-----	35
F	Perimeter heat loss factor.-----	35
P	The building perimeter.-----	35
η_{TW}	system efficiency.-----	36
R_o	The thermal resistance of outer air.-----	38
R_g	The thermal resistance of glass layer.-----	38
R_a	The thermal resistance of air gap.-----	38
R_c	The thermal resistance of concrete layer.-----	38
R_s	the thermal resistance of gypsum board.-----	39
R_b	the thermal resistance of bricks.-----	39
R_i	the thermal resistance of inner air.-----	39
h_o	the air coefficient of outer surface.-----	39
h_i	the air coefficient of inner surface.-----	39
k_g	the thermal conductivity of glass layer.-----	39
k_a	the thermal conductivity of air gap.-----	39
k_c	the thermal conductivity of concrete layer.-----	39
k_s	the thermal conductivity of gypsum board.-----	39
k_b	the thermal conductivity of bricks.-----	39
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t_{db}	dry bulb temperature.-----	40
ϕ	Relative humidity.-----	40

I. INTRODUCTION

Generally, climate control is of great importance for agricultural production in order to achieve high yield, good quality crops and develop production of animals. The quality of the environment in agricultural buildings is governed by such factors as temperature, moisture and air quality. The effects of temperature and humidity are often limiting the development production and reproduction of animals. Thermal stress acts as a limiting factor for maximum efficiency production and may interfere with reproductive rates and the production of meat and milk and increases rates of mortality. Effective temperature is particularly useful when the air temperature is below or above the thermal comfort zone. Ventilation is very important to provide fresh air necessary to maintain acceptable air-quality levels, where air is driven in/out of the closed area because of pressure differences across the openings. Using passive ventilation by what is called a "Trombe Wall" uses solar energy because the energy is too expensive and may not be available. There are problems in providing a healthy environment and reproductive systems for small animals to give higher productivity, under controlled environmental conditions, using available natural resources and sustainable economy under Egyptian environmental conditions.

The aim of this research is to study engineering factors for a natural ventilation system, depending on roles warming to provide the appropriate conditions for rabbit housing.

II. REVIEW OF LITERATURE

The impacts of climate on animal production include the effect of extreme climates as well as the effect of global climatic changes.

In arid and semi-arid regions, high ambient temperature accompanied with scarcity of water affects significantly animal production to be about 2-4% of world meat, milk and egg production. In semi-arid regions, and that additional heat stress will damage crops and especially livestock (**Lacetera, 2003**). In humid tropical regions, **Valtorta (2002)** has discussed the direct and indirect impacts of climate on animal production.

According to climatic change scenarios, milk production in hot/hot-humid southern regions of United States might decline by 5-14%; conception rate will be reduced by 36% and short-term extreme events (e.g. summer heat wave and winter storms) can result in the death of vulnerable animals (**IPCC, 2001**).

2-1 Climatic factors affecting livestock

Climatic factors affecting livestock climatic regions can be classified according to its effect on animals to: hot, cold and altitude (Table 1-3).

Hahn et al. (2003) demonstrated that the main natural physical environmental factors affecting livestock are: air temperature, relative humidity, radiant heat, precipitation, atmospheric pressure, ultraviolet light, wind velocity and dust. Impacts of climatic factors on farm animal production, reproduction, morbidity and mortality are illustrated in Tables (2-4-5). It is worth noting that the effect climate on farm animals depends greatly on the severity and duration of climatic factor and animal adaptive mechanism. Chronic heat stress for example affects animal morbidity, production and reproduction, while it has a slight effect on animal mortality.