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Cooling Buildings Using A Geothermal and underwater piping systems techniques (Hot and Dry weathers)

ABSTRACT

The conventional cooling systems in hot and dry climate regions are insufficient and could not meet the requirements of the summer season severe conditions. The low cooling efficiency of such systems can be promoted by combining the systems with an earth and water heat exchanger systems. The present study aims to achieve a proper environment for cooling the living buildings. This target could be achieved by using a geothermal system. The environment conditions are tested. The tests are applied on carefully, for a single room, which is well-isolated using wood. This room is connected to two pipes, which is pass underground and underwater heat exchanger pipes. Solar intensity, ambient temperature, humidity, and temperatures in underground pipe, underwater pipe and the test chamber, all are recorded. All tests are carried out in April, may, June and July, respectively. The obtained results indicated that the air temperature inside the test room has been decreased by 40% compared with the case of unused of a heat exchanger. A comparison between the theoretical and experimental results is done. In addition, the results showed that the air-cooling temperature in the case of using an underground pipe is less with 3 ^{0}C degrees compared with that of the underwater pipe. The reduction in the air-cooling temperature compared with the ambient temperature is (12-18) degrees

Introduction

The Islamic civilization buildings have many different design characteristics, which take into consideration utilizing the natural change of the wind flow inside the buildings that helps in creating a comfortable condition. Development through history and the discovery of the natural energy resources (oil and gas) in addition to inventing the electrical instruments. All of that lead to replacement of the natural cooling systems with the modern one that cause an increase in the environmental pollution, costs, and exhausting energy. Development of the

industrial creates a global warming phenomenon, increasing the fuel costs and a political crisis. Using the electrical machines and devices is a heavy consumer of energy which considered an environmental pollutant. The consumption of energy can be limited by using colored glasses, painted walls and ceiling [1]. Energy consumption could be minimized by using a colored glass, painted walls and ceilings in light colors [2] Misguided ceilings [3]. Green roofs [4,5]. Buildings are responsible for emitting of about 70% of the sulfur oxides [6].

In the recent years most of the buildings are built of cement which can store heat. The mechanical systems of air conditioner consume high energy in order to maintain a comfortable environment in the closed place whereas the passive design of buildings is defined technically in which the air cooling is occurred without energy consumption by pumps and fans [7]. In the building, doors, windows, floors, walls and ceilings play an important role in determining the effectiveness and efficiency of its design considering heat reception in winter and rejected heat in summer. This can be achieved by using shading and isolation to minimize heat exchange between the inside and outside the door. Since the climate conditions in Iraq is considered too hot because of the increase of the sun intensity and the vast change and variation of the air temperature. For this reason, the passive techniques are used to decrease the effect of the climate impacts on buildings. These passive techniques use an insulating materials and air control system. And this help in saving energy and decreasing the demanded for cooling [8]. Ninety percentage of energy could be saved with using the passive buildings compared with the traditional one [9]. Therefore, using isolation ceiling, green ceiling or isolation with ceramic and polishing is very important. Splashing water on the mineral roofs during partially cloudy, hot, humid day weather could also reduce the indoor temperatures [10].

Vegetation's (trees and plants) around buildings give a positive result which decrease emission and drop-down temperature in addition to offering a decorative site and approve the buildings sight [11].

Saving energy could reach 24% of heat during June provided that trees are planted on the southern and western side of the model house [12]. In spite of the positive results of the previous research regarding energy-saving refrigeration techniques, the economic aspects had not been studied. For cooling technology, using a wood wall in the worst cases like very high heat, the lack of rain and total mechanical irrigation, where the cost of planting and sustaining trees, disease and pest control, irrigation and purchasing of materials has been studied [13]. The economic study is considered as one of the important main things for most projects to save money, and energy, and decrease emission.

An analysis study of the energy and costs using a photovoltaic system with a Trumb wall in the climate using different types of photoelectric glasses. The results show that decreasing of the cooling load and CO_2 emissions when using Trumb wall with double glass filled with Argon gas. [14].

Most researchers have directed their attention to the use of heat exchanger and solar collectors which are placed in the front of the building southward, in order to get a high solar intensity. This is due to the solar collectors intensity is the main feature of using the solar collectors. [15]. an empirical study has been carried out in Iraq using two models: the first one is designed in a traditional method, and the second model is designed in a method of passive home type. The results indicated that the possibility of reducing the room temperature to be 31^{o} C by using a passive house instead of 42 ^{o}C in the case of the traditional house. And the energy consumption could be reduced to be 80% [16]. Engineers meet many problems in the design of the passive cooling systems merged in the buildings because of many difficulties due to the change in the built-in design and using these systems in an unsuitable circumstance.

The objective of this work is to overcome the difficulties of using the traditional methods for conditioning the house, these methods are air conditioning and water-cooling system. This is due to the extreme weather of Iraq especially with the very high temperature during the summer season. And utilizing the solar energy in an economical way. It is suggested to use one of these two alternatives. Supplying air to the house by pipes. These pipes pass through either;

- A sump of a circulated water
- The earth soil where the pipe lays three meters underneath the ground surface

In both cases, exchanging heat would happen. In the first between the pipe and the water, which is called Water Heat Exchanger and in the second, heat exchange would happen between the pipe and the soil which is then called Ground Heat Exchanger .

Blowing air through the pipes and ventilating air by the indoor part of the cooling system, both are achieved by utilizing the solar energy.

Nomenclature *Subscripts*

Re Reynolds Number
μ Dynamic viscosity (Ns/m)
V Velocity (m/s)
Nu Nusselt number
Pr Prandtl number
h Heat transfer coefficient ($w/m^2 k$)
k Thermal conductivity (w/m k)
D Diameter (m)
T temperature (^{o} C)
m• mass flow rate (kg/s)
$\dot{Q}$ Airflow rate in the tube (m^3 /hr)
Lt Thermal entry length (m)
L Length of the Pipe (m)
An Area (m^2)
Eff Cooling effectiveness (%)
HE Heat exchanger
UG Under ground
UW Under water
RH Relative humidity (%)
i inlet
out outlet
s surface
w water
g ground

Methodology

Materials and Equipment's

The purpose of the present research is to design an improved a cooling system based on selecting two heat exchanger pipes. The two pipes specifications and the operating conditions are explained in the following sections. The cooling system consists test room, fan, two heat exchanger pipes, pumping, water sump, and trench ditch. Underground pipe which is made from aluminum of 0.074 m (3 inches) diameter and 15 m length, and the underwater pipe is made of aluminum of 0.074 m (3 inches) diameter and 9 m length.

Data collections

All the system data such as, design and work parameters are recorded using three sensors: solar meter, temperature and humidity sensors. All the materials, which are used in this research, are available in the local market, simple, lightweight and easy to install. To achieve the aim of this research, many tests are carried out to determine the optimum variables of design and work conditions. All the tests are carried out in Tikrit City (34.6158^o N, 43.678^o E), where the climate is hot and dry. The tests are carried out in April, May, June and July, where the climate is hot and dry during these months.

Site of Test

Climate of Tikrit city is hot and dry with annual average ambient temperature of 32 °C. The climate of Tikrit city (34. 35°N, 43.37°E) is diverse, hot and dry in spring and summer (April-July) with a maximum air temperature up to 44^{0}C. The other metrological data (Sunshine period, solar intensity, maximum and minimum temperature) are measured and presented in Table 1.

Table 1: Metrological data that measured for Tikrit

Month	Mean sunshine period (hours)	Mean solar intensity (w/m^2)	Mean temp. (Max) ^{0}C	Mean temp. (Min) ^{0}C
April	8.3	680	28	18
May	9.5	700	34	24
June	11.2	755	41	28
July	10.9	770	44.	30
August	9.5	720	42	29

Experimental set up

The experimental setup for the system consists an Underground and underwater air heat exchanger pipes that connected to the east side of the test room. The test room dimensions are (2.1 m × 1.0 m × 1.1 m) (length × width × height) of two windows of (0.3 m × 0.3 m) on the south and north facing wall and a door of (1.0 m × 0.8 m) on the west-side walls. To prevent the ambient heat losses, a thermo cool insulation is placed on the interstices around the door as well as on the glass panes of windows. The experimental setup, as shown in Figs. 1 and 2, comprises two pipes, horizontal galvanized Aluminum pipe of (0.074 m (3 inches) diameter, 15m length) buried on a flatl and, dry soil at a depth of 3.0 m. and Aluminum pipe (0.074 m (3 inches) diameter, 9 m length) that immersed in water. At the inlet, open end of these pipes is connected to 180 W single phase motor of 2750 RPM, 0.055 m^3/s blowers. At its rated speed, the blower runs at 250 V and provides maximum flow velocity of 12 m/s inside each pipe. The outlet pipes are connected to the test room as shown in Fig. 2. Air flow velocity through the pipes could be varied by changing the blower speed with the help of an autotransformer (single phase, 0–220V, 0.7A maximum current, with a least count of 1V). Five thermocouples sensors were inserted at a fixed interval along the 3 m depth (starting from the ground surface) of pipe. These intervals are 0 m, 0.25 m, 0.5 m, 1.0 m, and 3.0 m, respectively. Other Three temperature sensors are fixed at the inlet, outlet and inside the test room.

Test methodology experiments and simulation

Underground and underwater heat exchangers pipes are simulated to show the effect of variations of the flow rate changes, pipe diameter, pipe length, the temperature and humidity. At the time of experimentation, these scenarios were followed for different test conditions as described below:

(1) **Test-I** (Operated on 7, 15 and 21 May): In this test, only thermal conditions (ceiling cover and green trees as shown in Figure.3 a, b and c) of the room and ambient were monitored.
(2) **Test-II** (Operated on 7, 15, and, 21 June): In this test the (conditioned air) from the underground heat exchanger pipe is directly supplied to the room. As shown in Figure.3 d and e

(3) **Test-III** (Operated on 7, 15, and, 21 July): In this test, the (conditioned air) from the underwater heat exchanger pipe is directly supplied to the room.as shown in Figure.3 f.
The system test was conducted along the period, April to July 2018 for 8-hour duration daily from 8 a.m. to 4 p.m. The air flow velocities through both tubes were maintained to be 2.5 m/s, 3.5 m/s and 5 m/For each case, the observed temperatures values of all the sensors (ambient, outlet pipes of heat exchanger and test room), solar intensity, ambient relative humidity and test room relative humidity were recorded hourly.

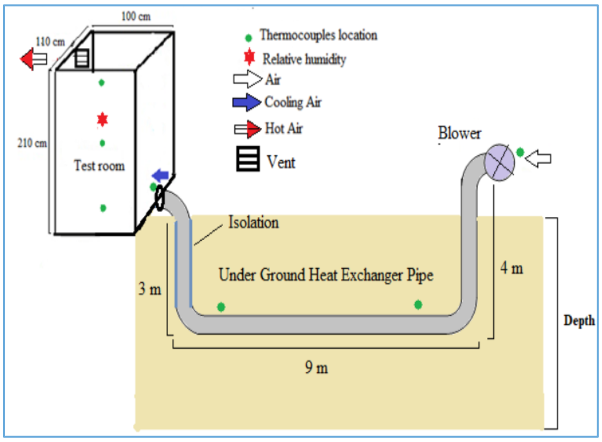


Fig.1: Underground heat exchanger pipe with thermocouple and humidity sensor.

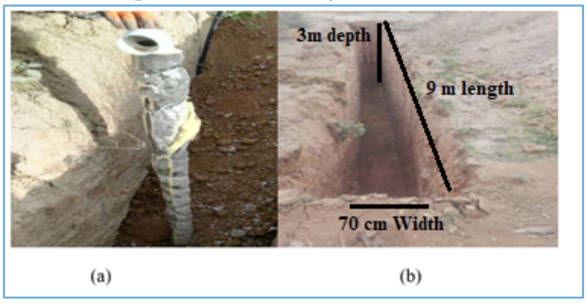


Fig. 2.(a) Underground heat exchanger, (b) Underground channel (3 meter depth)

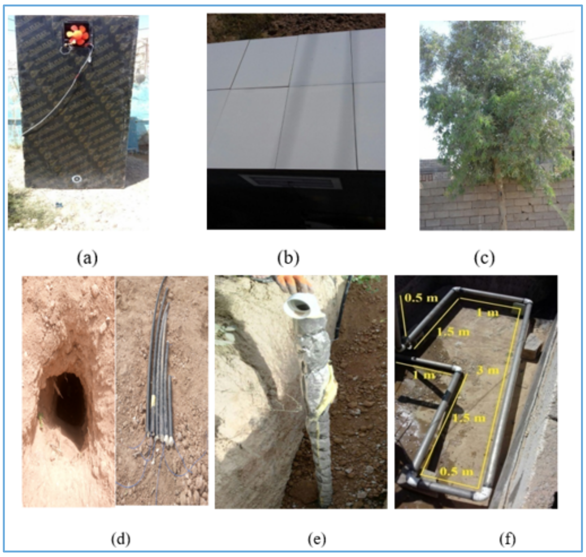


Fig.3 (a) Test room without isolation (b) Roof insulation with white ceramic glass (c) Using green Trees (d) Temperature sensors at different depths, (e) Under Ground plastic pipe, (f) Under Water aluminum pipe

Design of the Underground Heat Exchanger Pipe

The heat exchanger consists of 0.074 m (3 inches) diameter and 15 m length aluminum tubes. The ground heat exchanger is buried at 3 m depth underground. Each pipe is connected to a fan at 1 m above the ground surface to maintain the air flow inside the tube, and the second end of the tube is connected to the test room which is made of wood frame of (210 x 100 x 110) cm dimensions. This system is illustrated in Figs 1. and 2.

Design of the Underwater Heat Exchanger Pipe

The heat exchanger, which consists of aluminum tubes of 0.074 m (3 inches) diameter and 9 m length. The heat exchanger placed in a water sump (4x1.5x1.7) m dimensions, which is filled with water. One of the pipe ends is connected to the room and the other one is connected to a variable speed blower and the pipe is immersed inside the water sump as shown in Fig.4. Temperature and humidity are recorded inside and outside of the room at June 2018.

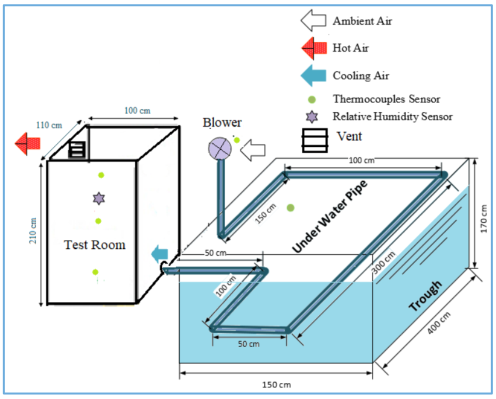


Fig. 4 Under water heat exchanger pipe with thermocouple and humidity sensor

One of the most important part of planning any cooling or heating system for buildings is the determination of the size of the system. The following conditions are taken into account: weather conditions (temperature and wind); desired inside temperature; what is the building made of (wood frame, adobe, brick, etc.), and how well it is made; areas of wall, ceiling, floors, windows, and doors; volume of each room; the placement of exterior windows and doors; volume of each room; the placement of exterior windows and doors, and heating system specifications. This information forms the basis of what is called a heat balance which will help us to find the heating system size of virtual building.

3.1 Modeling and Analysis

ANSYS and MATLAB software have been used to model the system check and compare with the tests results using water heat exchanger pipe [17-20]. The following is a sample of calculation:

$$Re = \frac{\rho V D}{\mu} \quad (1)$$

For turbulent flow the thermal entry length and Nusselt number correlations are written as:

$$Lt = 10 \times D \quad (2)$$

$$Nu = 0.023\, Re^{0.8}\, Pr^{n} \quad (3)$$

$n = 0.4$ for heating

$$h = Nu \frac{k}{D} \quad (4)$$

$$As = \pi DL \tag{5}$$

$$\dot{m} = \rho \times Ac \times V$$

$$Ac = 3.14 \times \frac{D^2}{4} \tag{6}$$

$$T_{out} = T_w - (T_w - T_{in}) exp\left(\frac{hAs}{mC_p}\right) \tag{7}$$

$$\eta = \frac{(T_{in} - T_{out})}{(T_{in} - T_w)} x100 \tag{8}$$

Tables 2 and 3 show input and output data respectively.

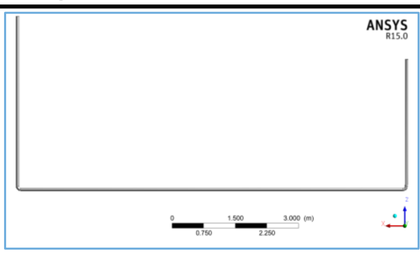
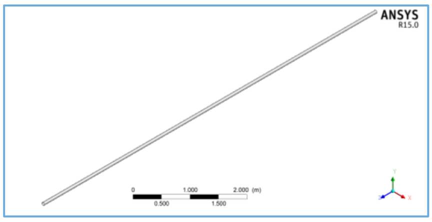
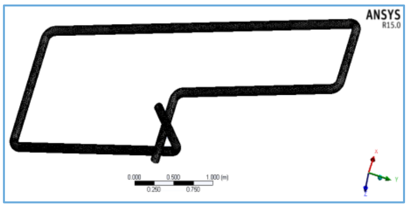
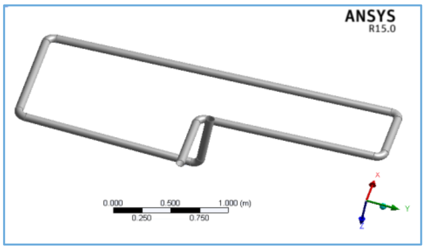
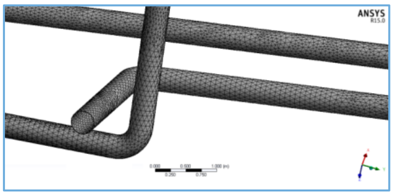
Table 2: input data

	Ta=Ti °C	D (m)	L(m)	T (°C)
UGP	37.6	0.075	15	25.17
UWP	37.6	0.075	9	26.8

Table 3: Output data

Flow rate				$\dot{Q}$=32 m³/hr			$\dot{Q}$=64 m³/hr			$\dot{Q}$=96 m³/hr		
Parameters	**Lt (m)**	**As (m²)**	**Nu**	**h w/m.k**	**Eff %**	**Tout °C**	**h w/m.k**	**Eff %**	**Tout °C**	**h w/m.k**	**Eff %**	**Tout °C**
UGP	0.75	3.53	56.4	19.9	97	25.54	19.4	96	25.4	27.8	95.9	25.7
UWP	0.75	2.11	56.4	19.9	87.7	28.12	19.4	87	28.17	27.8	85.7	28.3

Table 4: Simulation data required for ANSYS

Design modeler	**mesh**	**Boundary Condition**
	Nodes :27584 Elements:81942 Smoothing: Fine Transition: Slow	Pipe: Wall Outlet: Pressure outlet with zero static pressure
		Inlet: Velocity inlet Input data: L , D , V , Tin , Tg , Tw
		

Results and discussions

tests are conducted under weather conditions in Tikrit city (34.6158° N, 43.678° E). Tests were conducted during April, May, June, and July. The effect of the heat exchanger type as a cooling system either cooled by water or located in the soil at 3-meter depth, both are explained. In addition to that, the type of the isolation such as planting or covered by ceramic are also studied. The results are presented as follow:

Room temperature profile without HE

Measurement of the solar intensity values and the air temperatures distribution inside and outside the test room are conducted. These data are recorded without adding any techniques as mentioned previously. It is carried out for the condition of 2.5 m/sec air speed. Results are presented in Fig. 5. It shows that the variations of the temperature profile inside and outside is nearly the same and this is considered as a normal condition because there is no any enhancement. And this is an indication that the cooling enhancement is required.

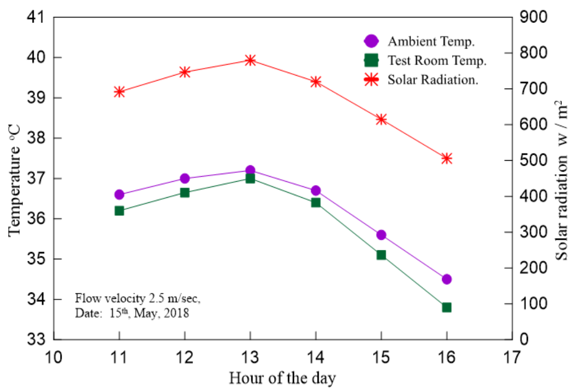


Fig.5 solar intensity and temperature profile

Room temperature profile with roof isolation and without HE

The second test is conducted with the use of an isolate ceiling of the test room with ceramic. Results of tests indicated that the temperature inside is less than the outside temperature with 3.5 °C. As shown in Fig 6. This temperature reduction is a result of using isolation ceiling which leads to reduce the heat gain through it.

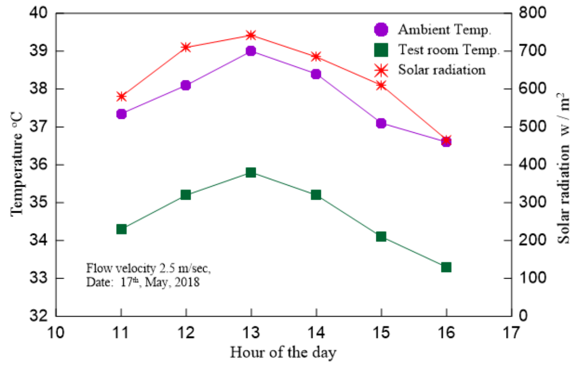


Fig. 6 the Effect of ceiling isolation on temperature profile

Room temperature profile with green trees and without HE

The third test was conducted using the same approach that used in the second test with using a green tree. The green trees made the test room under shadow without any change in the other parameters. The test results showed that the temperature values inside the test room decreases with 4 °C as shown in Fig. 7.

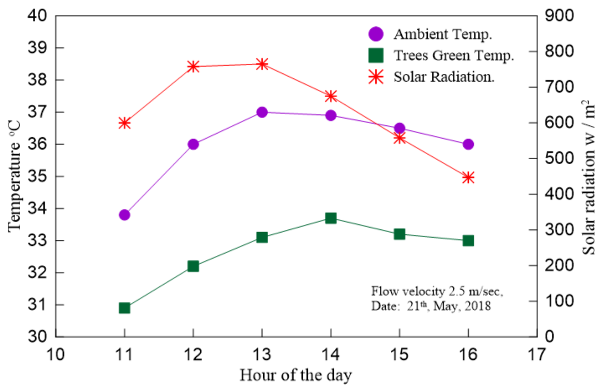


Fig.7 The Effect of the green trees on temperature profile.

The effect of the relative Humidity with different conditions

The humidity data values are recorded during the period (sunrise to sunset). Humidity profiles are plotted in Fig. 8. The maximum and minimum values of relative humidity are determined. All profiles have the same trends as isolations ceramic or green trees are utilized. However, as green tree is used, both the external and internal condition are influenced.

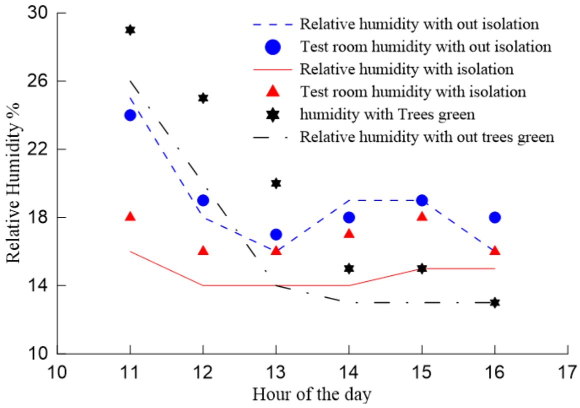


Fig. 8 Relative humidity profiles in the test room at the conditions of using isolation, and green trees

Effect of burial depth of the pipe

The experimental data are recorded in three different days, as shown in Table 5. They reveal temperature change (soil temperature at4 m depth under the ground surface level). It was observed that the diurnal variation in the ambient temperature and solar radiation does not affect the temperatures. The ground surface temperature was less than the ambient temperature and it decreases as the depth increases and finally converges to a constant value. The observed temperature at this burial depth is used to validate temperature obtained by Fluent simulation by 15.0.7 as shown in Fig.9. The tests were carried out over solar radiation intensity ranged from 100 to 760 W/m^2. The results showed that the minimum temperature is recorded for 3.0 m underground depth. The maximum recorded difference between the soil and the ambient temperature at 3.0 depths was 16 ^oC. This test is conducted in order to determine the best and useful depth for the heat exchanger pipe.

Table 5: Temperature at different depth (May 2018)

Location of temperature sensor	Measured Temperature at 12 p.m. (^0C)		
	7 May	**15 May**	**21 May**
4 m depth	23.3	23.4	23.3
3 m depth	23.3	23.3	23.4
1 m depth	25.4	25.5	25.5
0.5 m depth	27.5	27.4	27.4
0.25 m depth	29.4	29.3	29.2
at ground surface	35.4	34.5	36.0

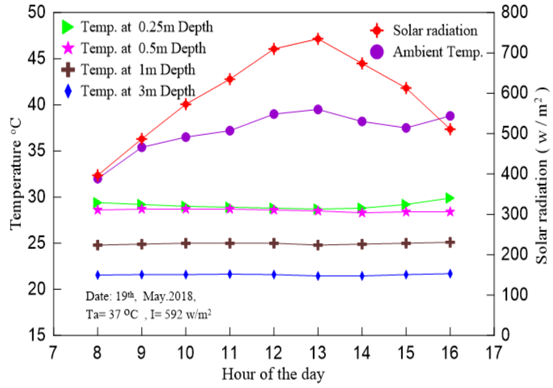


Fig.9 The effect of pipe depth on the air temperatures inside the test room

The effect of the airflow rate on its temperature inside the test room by using the underground heat exchange pipe

The airflow influences temperatures of the underground heat exchanger pipe and the air temperature inside the test room, both effects are presented in Fig. 10. Solar intensity and ambient air temperature are plotted with the heat exchanger temperature and the test room. Results show that the maximum reduction in the air temperature inside the test room occurs at the flow rate of 32 m^3/hr. and this reduction is not an optimum value, but it is related to the design parameters such as pipe length, diameter, material, and work conditions like flow rate. In addition, the cooling process which is conducted by the airflow inside the pipe depends on the thermal resistance between the airflow inside the pipe and its walls. This process is necessary to determine the optimum conditions inside the test room.

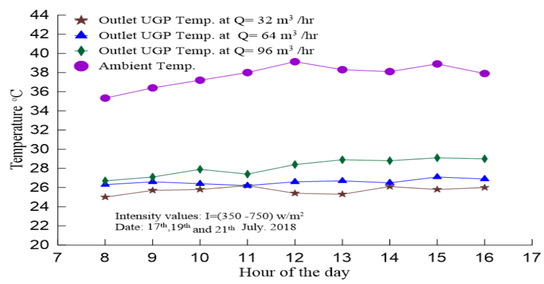


Fig. 10 Effect of the air Flow rate on the outlet underground temperature profile.

Comparison between different airflow rates

Fig. 10 shows the temperature profiles of the experiments results for the airflow rates (32, 64, and 96) m^3/hr respectively. The tests were carried out at constant pipe temperature of the underground heat exchanger and solar radiation intensity range (350 - 750W/m^2). Both, the modeled one and the experiment results show a similar temperature patterns of the underground and the underwater heat exchanger pipes at a wide range of the environmental conditions. Table 5 shows a sample of tests of temperatures profiles at different conditions.

Effect of pipe diameter and length for the underground heat exchanger on the test room air temperature

Fig.11 shows the test room temperature variation along the day hours, for different pipe diameters. From this figure, it can be seen that room temperature varies proportionally at morning hours, while almost constant during afternoon hours. In addition, a peak value is noticed at eleven o'clock AM. Also, it could be seen that the pipe diameter effect on the temperature difference between the room and ambient temperature are at the following decreasing order (3, 4, 6 and 8 inch). i.e., using a small diameter pipe gave the best efficiency of thermal exchange. Fig. 12 shows the test room temperature variation during the day hours for different pipe lengths. This Figure shows the same temperature variation curves behaviors of Fig.12. Curves. Moreover, from this figure it is obvious that the longest pipe has the optimum performance among all sizes.

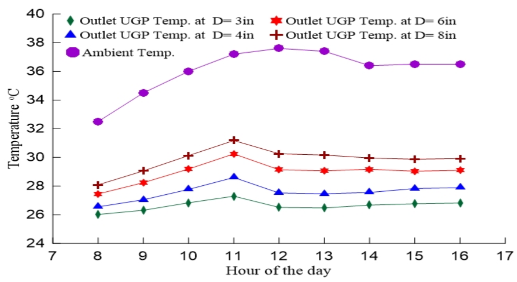


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Fig. 11 Test room temperature variation over a day.(Underground simulation results)

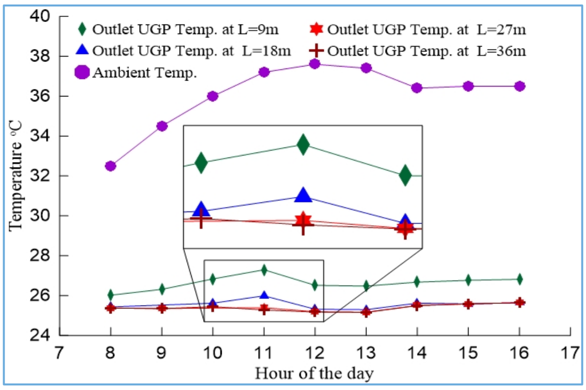

Fig. 12. Test room temperature variation along the day hours (Underground simulation results)

4.9 The effect of using the underwater heat exchange pipe.

The third part of the study was conducted, in two pipes of the same length and diameters. Both are made from a galvanized aluminum. These pipes are immersed in a water sump of 9 m^3 size. Each pipe was tested separately. Both ends of the two pipes are open above the water surface level. The ambient airflow enters through one end of the pipe and exit through the other, which is connected, to the test room. The process of air-cooling happens through the airflow inside the pipe. The reduction in the ambient air temperature depends on the length, and diameter, of the pipe that immersed inside the water sump temperature and the air temperature. The recorded data for water, test room air, and the ambient temperature all are presented in Fig. 13. These results showed that the maximum reduction in the ambient temperature of the test room is 40% for air flow rate 32 m^3/hr all are presented in Fig. 14.

Fig. 15 illustrates the variation of the room and ambient temperature during the day hours at the following pipe diameter (4, 6 and 8 inch). It is clear that the using of a small pipe diameter gave the lowest temperature ranges because it is increased the internal air velocity, then gave the best effective of thermal exchange. Fig. 16 shows the variation of test room temperatures during the day hours for different pipe lengths. From this figure it is clear that the longest pipe has the best performance among all lengths because it is increased the surface area of thermal exchange.

Table 6: Temperature values of the underwater and undergrounds pipe and test room in 14th ,15th, and 16th June /2018 at Q= 32 m^3 /hr

Time (PM)	Ta (°C)	olar itensity W/m^2	TUGP (°C)	TUWP (°C)	Test room at TUGP (°C)	Test room at TUWP (°C)
12	28.0	695	25.4	27.7	31.4	39.0
1	27.9	752	25.3	28.4	31.6	40.2
2	29.0	612	26.1	28.3	31.3	39.3
3	28.2	507	25.8	28.6	30.6	38.6
4	27.7	516	26	28.7	30.3	39.8

Where;
TUWP: Underwater pipe
TUGP: Underground pipe
Ta: ambient temperature

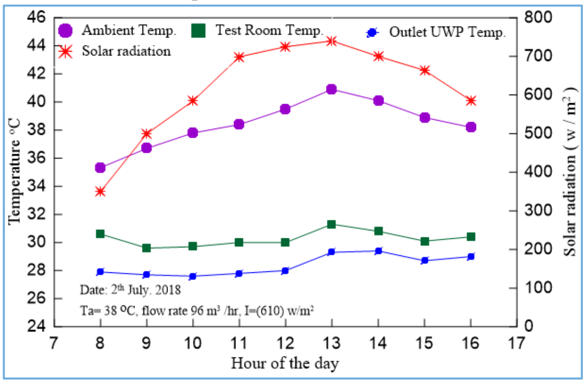

Fig. 13 Test room temperature variation over a day.

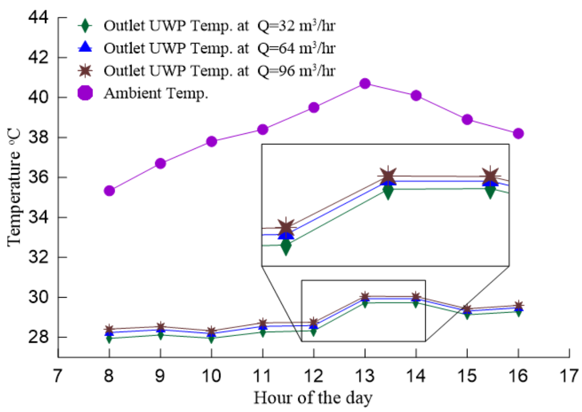

Fig. 14 Effect of the airflow rate on temperature inside the test room using under water pipe (Underwater simulation results)

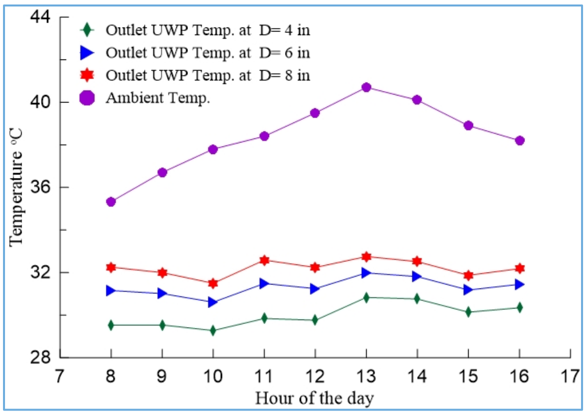

Fig. 15 Effect of the pipe diameter on the air temperature inside the test room by using under water pipe (Underwater simulation results).

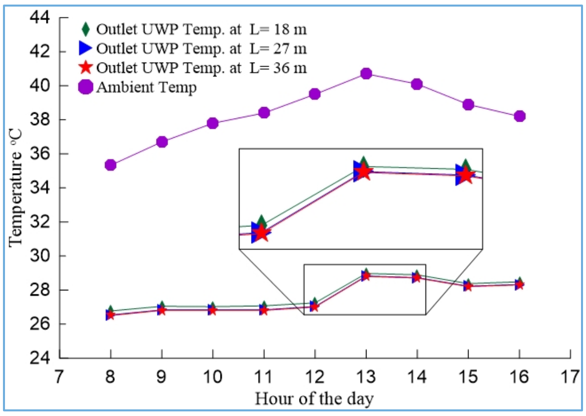

Fig. 16 Effect of the pipe length on its temperature inside the test room by using under water pipe (Underwater simulation results)

of the underground and underwater heat exchanger on the relative humidity

The test results of the outlet temperature of the Underground, underwater heat exchanger pipes and the test room; all are plotted in Figs 17 and 18. The results showed that the outlet temperatures of the under groundwater are less than that of the Underground pipe. These results showed that the test room temperatures (using underwater pipe) is lower by 20% compared with the use of the underground pipe. it could be concluded that, reaching the desired temperature for the outlet air, this could be achieved by increasing the length of the underwater pipe length. Also, it could be noticed that the relative humidity values have the following values, 33.8%, 30.3% and 17.4%, for using the under ground heat exchangers, under water heat exchanger and the ambient rspectively. Fig.17 shows the temperature variation over the day hours for, solar radiation, ambient, underground pipe and under water pipe respectively. It could be noticed that the temperature drops down by using the water heat exchanger more than for using the earth heat exchanger. This is because water thermal conductivity is higher than that of the soil, especially with aluminum pipes, which gives almost the same temperature for both, pipe surface and the water. Hence the airflow shows a negligible effect on the water temperature. Wherea, for the ground heat exchanger since the air flow rate has a large value, this require a larger pipe to offer enough time for heat exchange. Therefore, the test room temperature using water heat exchanger is less than that for using an underground heat exchanger as shown in Fig.18. Fig. 19 shows the relative humidity variation along the day for, ambient, test room, using an underground and an under-water pipes. The recorded values are for 32 m^3/hr air flow rate of different flow rate values.

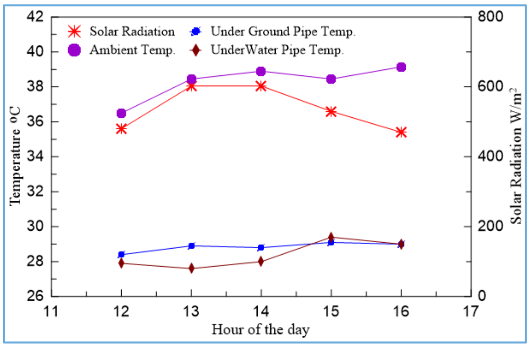

Fig. 17 Test room temperature variation over a day.

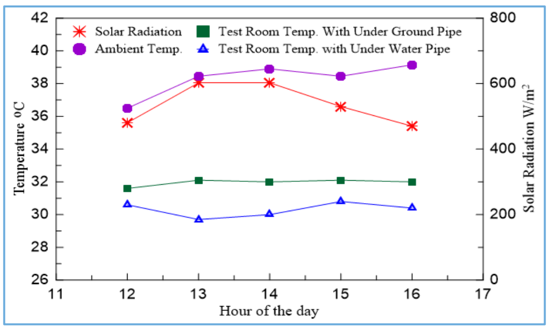

Fig.18 A Comparison between the Test Room Temperatures variation, for using the underground and the underwater pipes.

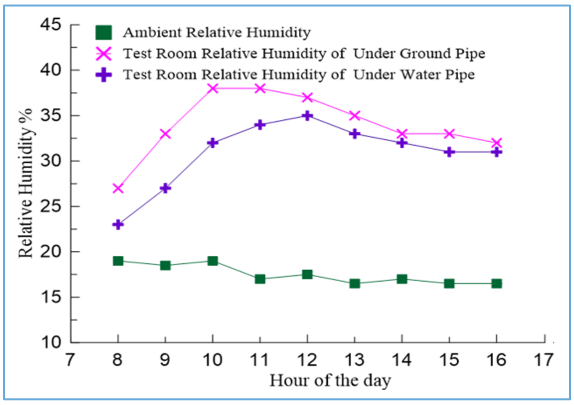

Fig. 19 A Comparison between the relative humidity variation of the ambient and the test room, using the underwater and the underground heat exchanger pipes.

A Comparison between experimental and theoretical results

Fig. 20 show the experimental and the theoretical cooling effectiveness variation during the day hours. This is for using an underground heat exchanger of 0.074 m (3 inch) pipe diameter and 32 m^3/hr air. Are flow rate. It could be noticed that a high variation (theoretical) in the cooling effectiveness value, especially at the morning hours. This is related to the fast change of the ambient air temperature during the morning hours. The highest registered value for the experimental cooling effectiveness was 96.1% at 8 a.m.. Also, the highest difference value between the experimental and the theoretical cooling effectiveness is 8.2%. Table 7 shows a comparison between experimental and theoretical results at different flow rates. .

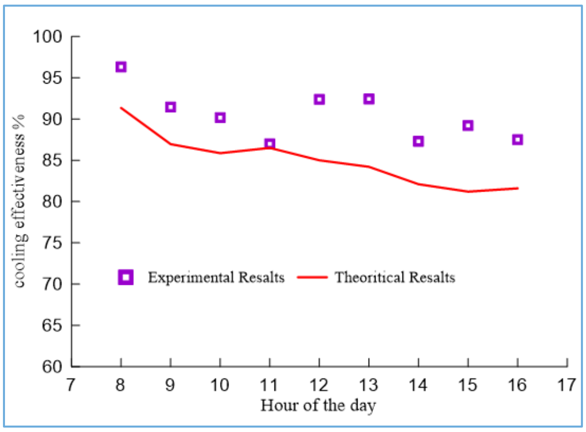

Fig 20. Cooling effectiveness variations over a day hours.
(Flow rate 32 m^3 /hr, using underground heat exchanger).

Table 7. A comparison between the experimental and the theoretical results at different

Time	Air Velocity = 2 m/s , Q=32 m^3/hr			Air Velocity = 4 m/s , Q=64 m^3/hr			Air Velocity = 6 m/s , Q=96 m^3/hr		
	Exp. Temp.	**Cal. Temp.**	**% different**	**Exp. Temp.**	**Cal. Temp.**	**% different**	**Exp. Temp.**	**Cal. Temp.**	% different
8	25	26	3.8	26.3	25.8	1.9	26.7	25.9	**3.08**
9	25.7	26.3	2.28	26.6	26.8	0.74	27.1	26.7	**1.49**
10	25.8	26.8	3.7	26.4	27.1	2.58	27.9	27.6	**1.08**
11	26.2	26.4	0.75	26.2	27.1	3.32	27.4	27.8	**1.43**
12	25.4	26.5	4.15	26.6	27.3	2.56	28.4	27.9	**1.79**
13	25.3	26.5	4.52	26.7	27.3	2.19	28.9	27.9	**3.58**
14	26.1	26.7	2.24	26.5	27.4	3.28	28.8	28.1	**2.49**
15	25.8	26.8	3.7	27.1	27.2	0.36	29.1	28	**3.9**
16	26	26.8	2.98	26.9	27.3	1.46	29	27.7	**4.69**
Average	25.7	26.5	2.14	26.58	27	1.31	28.1	27.5	**1.9**

Simulation results

Figs. 21 and 22 show the temperature variation of the test room during the day hours, for the case of using the underwater heat exchanger. These Figures are corresponding to the previous Figures 15 and 16. And give the same temperature behavior and trends of those Figures with more fluctuation.

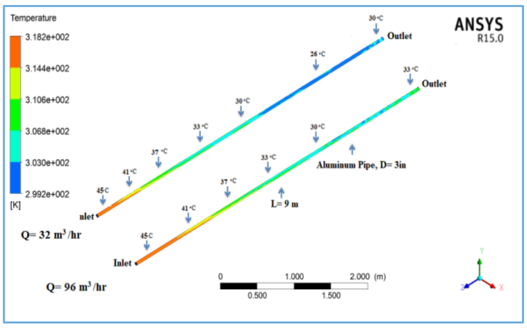

Fig. 21 Simulation results of temperature distribution along the underground pipe with length 9 m, 0.075 m diameter

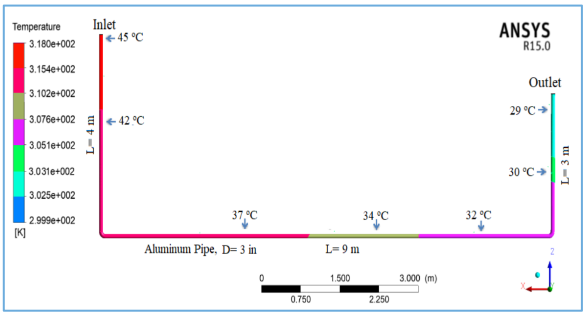

Fig. 22 Simulation results of temperature distribution along the underground pipe with length 9 m, 0.075 m diameter

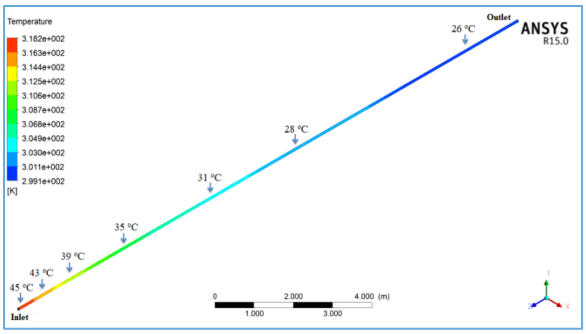

Fig. 23 Simulation results of Temperature distribution along underground pipe with flow rate 32 m³ /hr, length 18 m and 0.075 m diameter

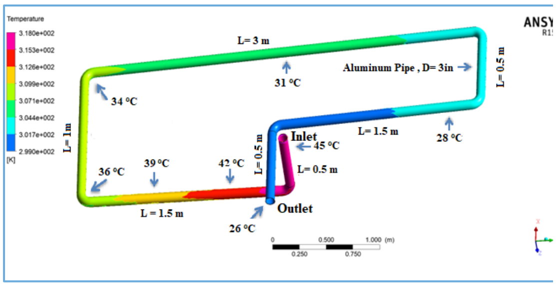

Fig. 24 Simulation results of Temperature distribution along underwater pipe with flow rate 96 m³ /hr, length 9 m and 3 m diameter.

Uncertainties & Error Analysis

In general, an uncertainty analysis is quite complicated process. Therefore, applying engineering judgment roles is the unique choice in some uncertainty calculations. This section summarizes the instrument calibrations and uncertainty calculations for the measured parameters such as temperature and solar intensity. All K-type thermocouples were calibrated against the standard temperature (i.e., the reference RTD) at a temperature range of 0 - 100ºC. These thermocouples assemblies were immersed in a liquid bath thermostat together with the RTD. For the reference RTD, the maximum uncertainty was ±0.3ºC. The uncertainty values of the instruments were estimated as follows. The bias error was calculated according to Fig liola and Beasley. Independent parameters, such as temperature, solar radiation, the bias error (A) and precision limit (P) were found by the collect root–sum–squares (RSS) method [21].

$$A = \pm[(\tfrac{1}{2} Resolution)^2 + (Accuracy)^2\ ]^{1/2}$$
(9)

The average value of the scale or the average of the measured value is expressed as;

$$\bar{B} = \tfrac{1}{n}\sum_{i=1}^{n} Bi$$
(10)

The standard deviations (σ) of the sample distribution is;

$$\sigma b = [\tfrac{1}{n-1}\sum_{i=1}^{n}(Bi-\bar{B})^2\ ]^{\ 1/2}$$
(11)

The mean standard deviations ($\sigma\bar{b}$) for the sample was deduced using the following relation:

$$\sigma\bar{b} = \frac{\sigma b}{\sqrt{n}}$$
(12)

To use t distribution at 95 % confidence interval with the (N-1) degrees of freedom, can found it from Table 8. The overall precision error limits can be written as;

$$\mathrm{Pb} = \mathrm{t}(\mathrm{N}-1), 95\% \times \sigma\bar{b}$$
(13)

Integration between the elemental errors was conducted to obtain the 95% confidence of uncertainty (Ub),

$$Ub = \pm[A^2 + Pb^2\ ]^{1/2}$$
(14)

The relative uncertainty (in percentage) is calculated as:

$$\frac{Ub}{B}\% = \pm(\frac{\mathrm{Ub}}{B})\times 100$$
(15)

In Eqs. 10 through 15 B is an independent parameter such as temperature, and solar intensity. The accuracy and resolution of Applent AT4808 Handheld MultiChannel Temperature Meter, and DAYSTAR DS-05 Solar Meter are 0.2% + 1°C, 0.1°C, and ± 3% (0 - 1200 W/m²), 1 W/m² respectively. Based on equations 9 through 15 the results of uncertainty are presented in Table 9.

$Table\ 8\ The\ value\ of\ (\ \mathrm{t}\ (\mathrm{N}-1), 95\%\ )$ [22].

Degrees of freedom	t 95 %	Degrees of freedom	t95 %
1	12.706	18	2.101
2	4.303	19	2.093
3	3.182	20	2.086
4	2.776	21	2.080
5	2.571	22	2.074
6	2.447	23	2.069
7	2.365	24	2.064
8	2.306	25	2.060
9	2.262	26	2.056
10	2.228	27	2.052
11	2.201	28	2.048
12	2.179	29	2.045
13	2.160	30	2.042
14	2.145	40	2.021
15	2.131	60	2.000
16	2.120	120	1.980
17	2.110	∞	1.960

Table 9: Sample of experimental tests uncertainty calculations

	Solar Intensity w/m^2	**Ta °C**	**RH %**	**Test Room °C**	**TUGP °C**	**TUWP**
A	±0.5	±0.05	±0.07	±0.05	±0.05	±0.05
$\bar{B}$	616.6	39.35	32.2	31.04	25.72	28.3
σb	108.12	0.64	0.83	0.559	0.35	0.339
$\bar{\sigma}$ b	54.06	0.32	0.41	0.279	0.17	0.169
Pb	138.99	0.82	1.16	0.719	0.45	0.43
Ub	138.99	0.82	1.16	0.72	0.46	0.43
(Ub/$\bar{B}$)%	±22.54	±2.10	±3.61	±2.32	±1.79	±1.55

Conclusions

The following conclusions may be deduced: In summary, this paper argued that the proposal design and the obtained results improve the weather conditions at the dry and hot regions. The present wok confirms that using of both approaches; underground and under water heat exchanger pipe, both reduce the test room temperature by 40% lower than the ambient air temperature. In addition, these works provide additional information about the use of the underground heat exchanger pipe in such systems and it was studies to decide if it is beneficial or not compared with the water heat exchanger pipe. This may be considered an alternative method of using such techniques in the cooling systems in the area of hot and dry weathers and under shortage. Future investigations are necessary to validate the conclusions this study. Thus, the use of such systems of air-cooling duct is very effective for air-cooling in summer as it may reduce energy consumption and carbon emission of active cooling systems in tropical climatic conditions. Installing the underground heat exchanger pipe is easier than the underwater pipe. The obtained efficiency in both, modelled and experimental results, are in an acceptable range (13% to 17%).

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