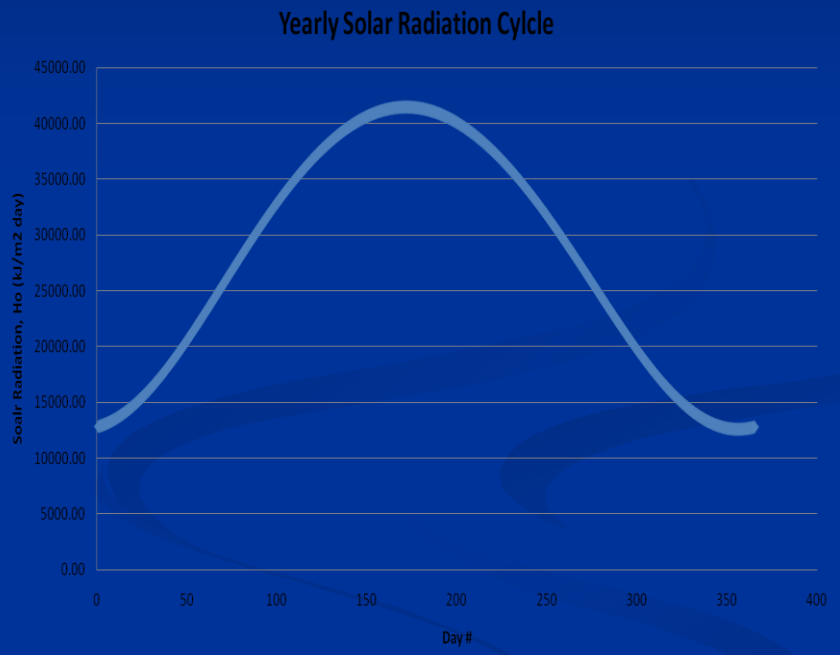
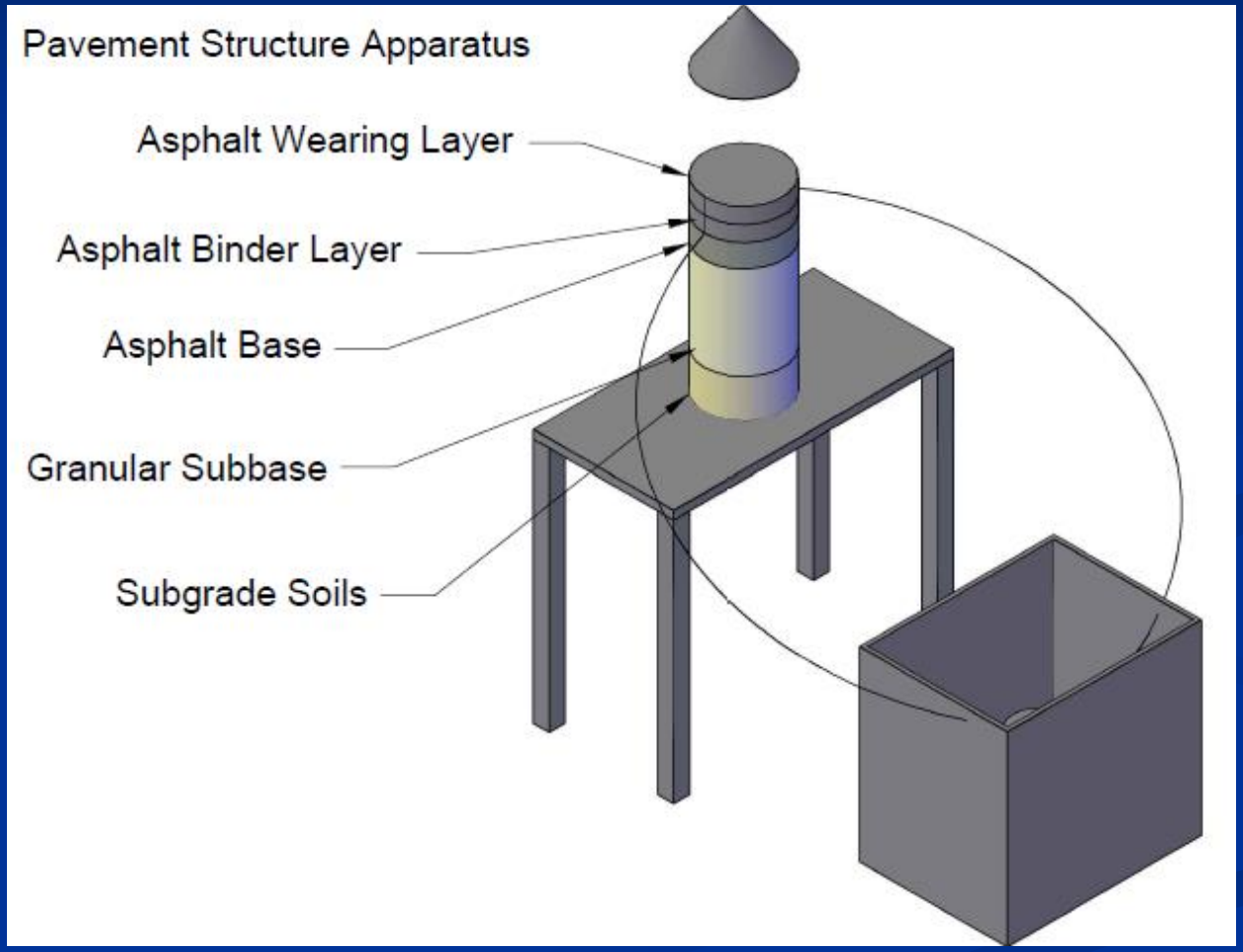
# Conductive Pipe Method

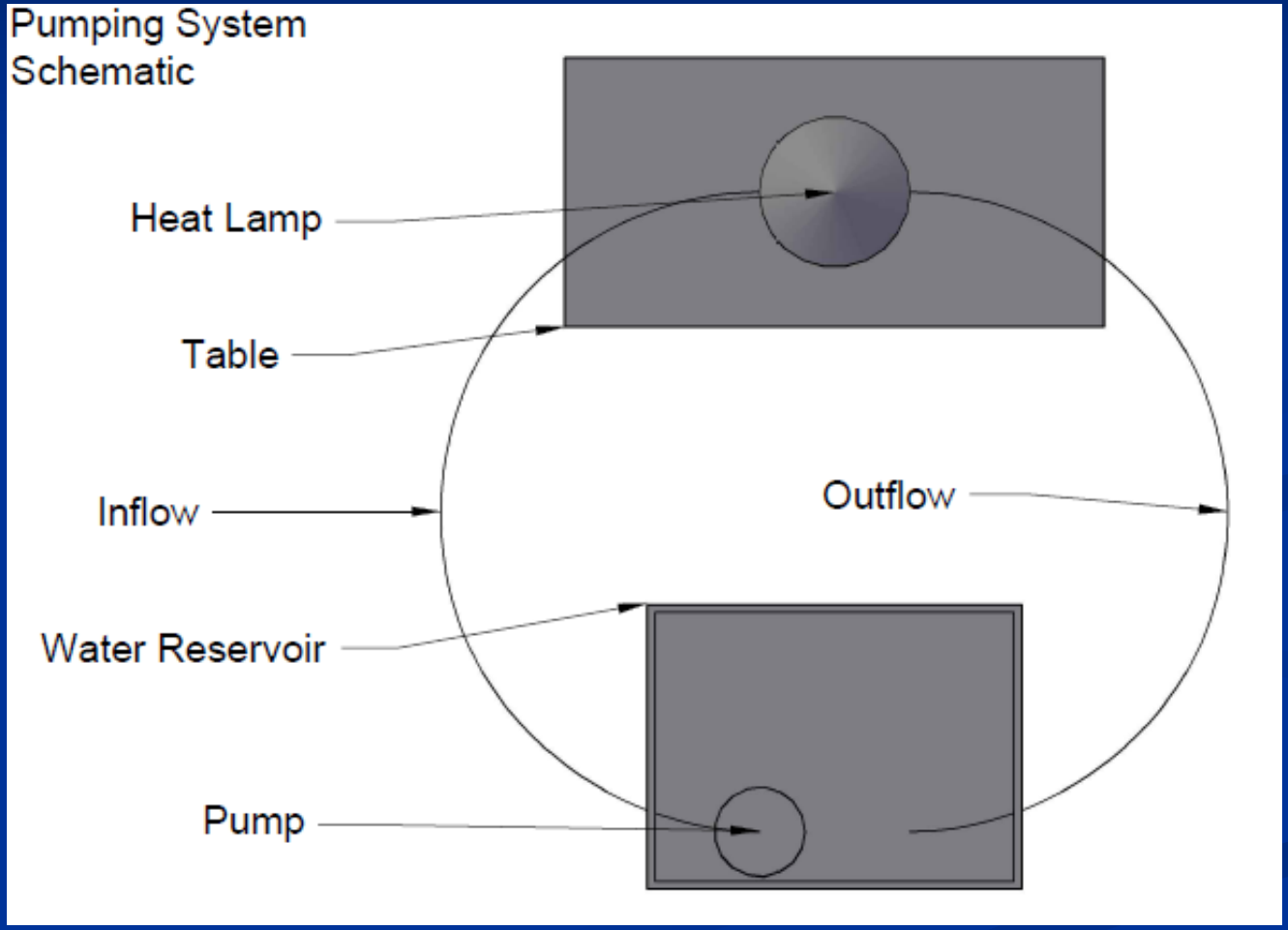
- Primary testing has been completed in a laboratory environment
- Using a sample pavement structure and simple pumping system testing was done to recreate similar research and field conditions
- Modified solar equations were used to approximate the solar exposure that would occur outside



# Conductive Pipe Method



# Conductive Pipe Method

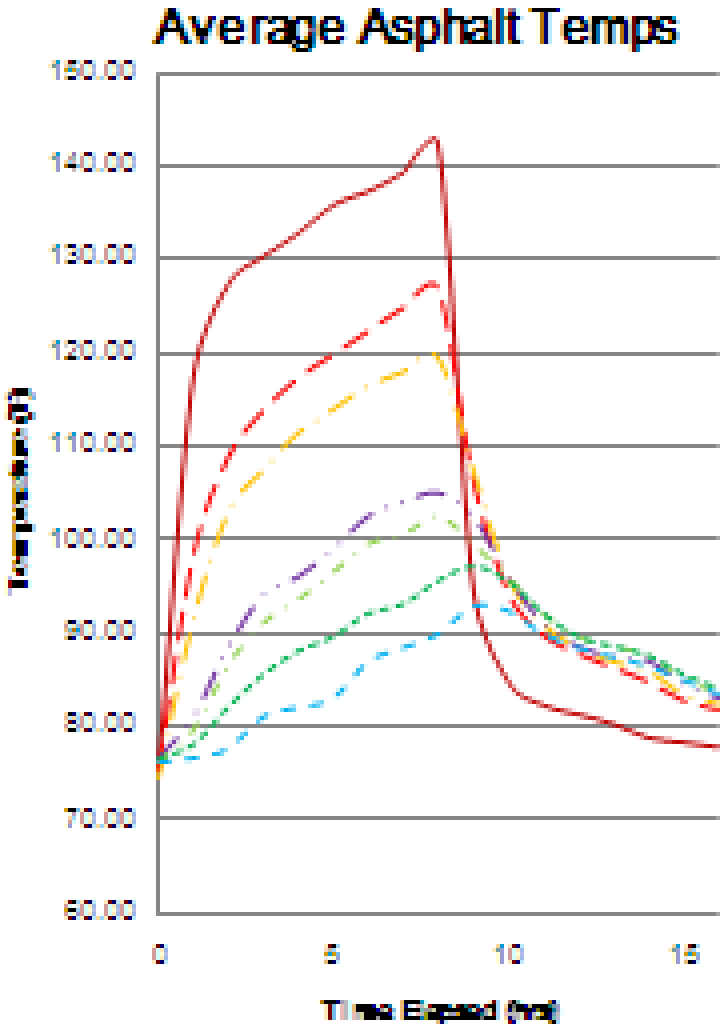


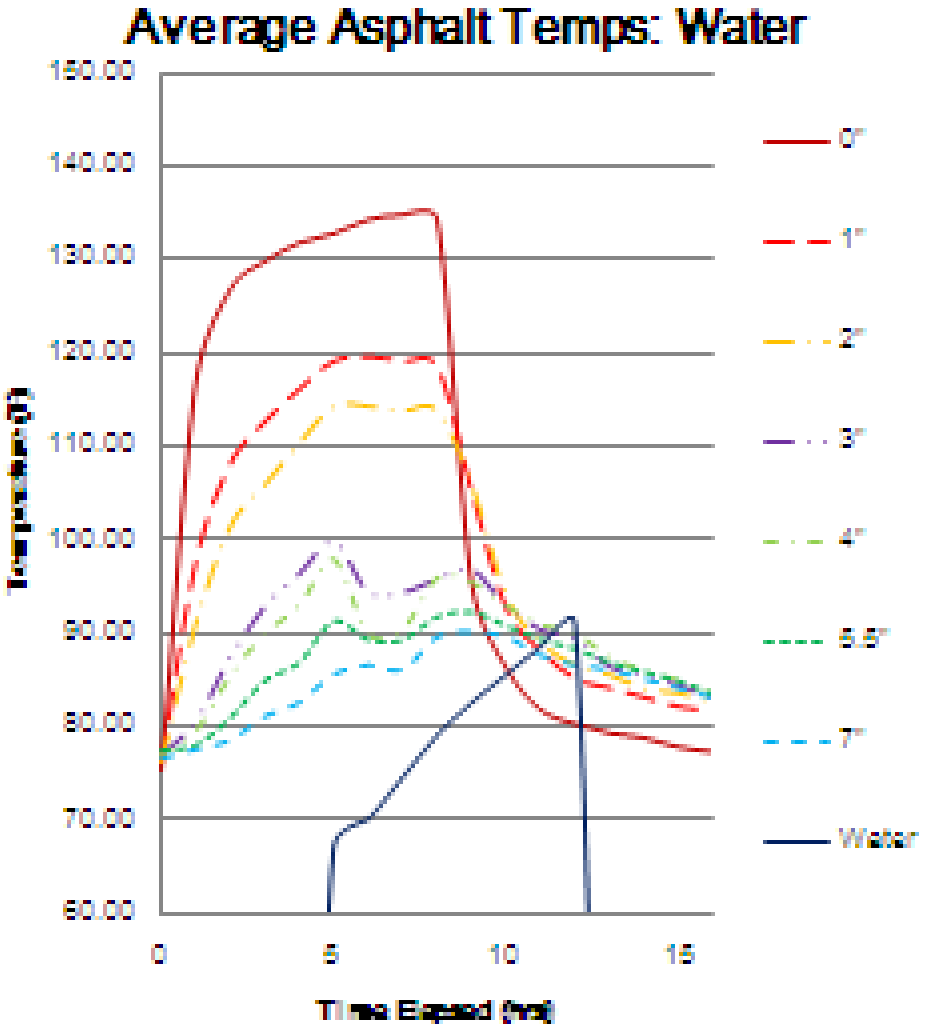
# Conductive Pipe Method


# Conductive Pipe Method

- Using thermocouples temperatures at different depths could be recorded and observed
- Heat was applied with the use of a basic heat lamp, and set at a height to recreate field solar exposure
- Two different types of testing
  - A typical day of solar radiation to grasp base values for future comparative studies
    - One "day" comprised of 8 hours with light, and 8 hours with no light
  - Water testing involved turning on the pumping system for an 8 hour period after 4 hours of light exposure to see if there was significant differences in temperature

# Conductive Pipe Method



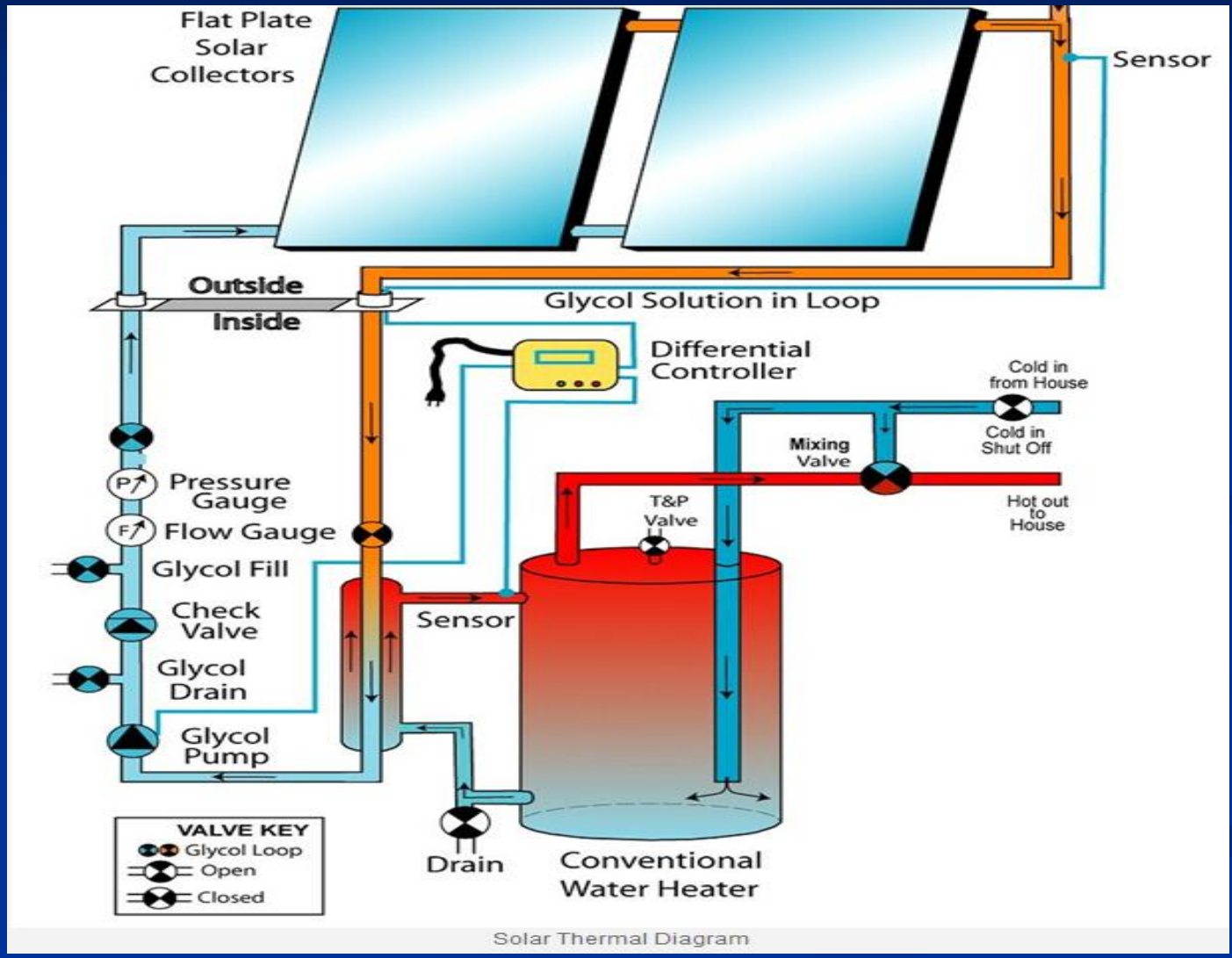
# Conductive Pipe Method

Most of the results complied with the estimation from research used, and can be used as a basis for future testing

- Only asphalt layers were directly affected by the solar exposure
- These asphalt layers held heat for lengths of time, even after no heat was applied
- There was definite heat transfer that occurred during the water system being turned on
- Variables (pipe diameter, pump duration, pipe thickness, etc) can be changed to focus more on heat extraction, as well as cooling the pavement

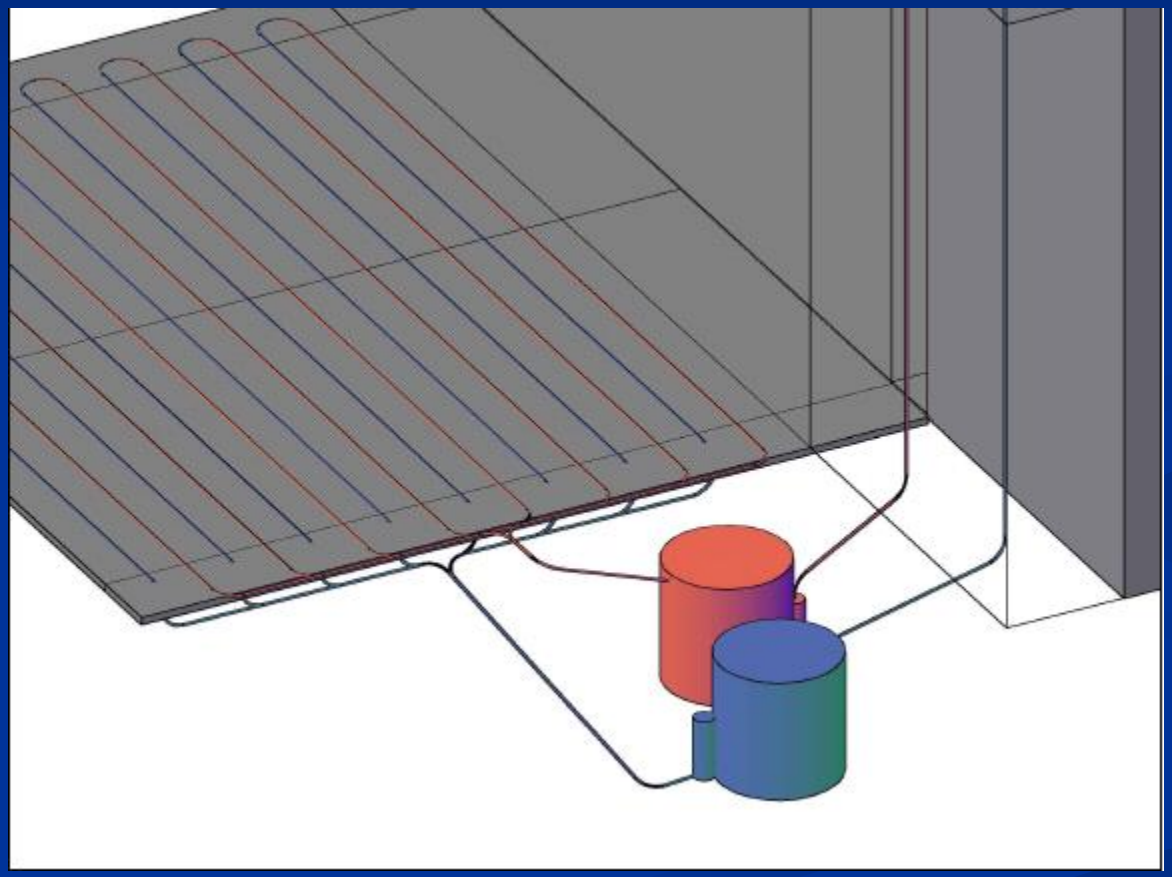
# Conductive Pipe Method

- Data from these experiments can theoretically be applied to designs for parking structures using asphalt pavement
  - Low volume will ensure low deformation and loss of color in asphalt
  - Exposure to sunlight is maximized do to little obstruction or traffic
- Application of hot water from pipes to icy bridges can lower dependency on salt and deicers
  - Can lead to long life spans of bridges in general
  - Pipes can be run parallel with roadway so as not to be obscured by traffic




Solar Thermal Diagram

# Conductive Pipe Method



## 2.1 Determination of Pipe Type

- Copper, PE, and Teflon pipes

Copper PE Teflon

## 2.1 Determination of Pipe Type

| TYPE | Advantages | Disadvantages | Selection |
|---|---|---|---|
| Copper | Heat extraction is excellent due to high heat transfer | - The pipe can be damaged during the installation of pipe<br>- High cost | |
| PE | Excellent workability during the installation | Weak to high heat during asphalt pavement construction. | |
| Teflon | Excellent workability and no deformation due to high heat during asphalt pavement constrcution | Similar price with copper pipe | ✓ |

## 2.2 Determination of Pipe Diameter

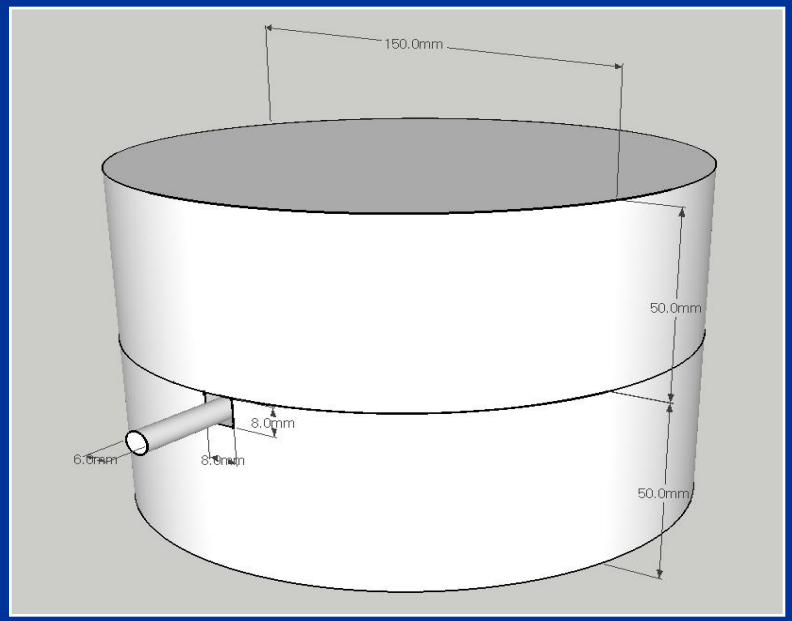
- When the pipe will be placed in the pavement, the larger diameter the faster absorbing the heat. But, it is not easy to have stable pavement structure.

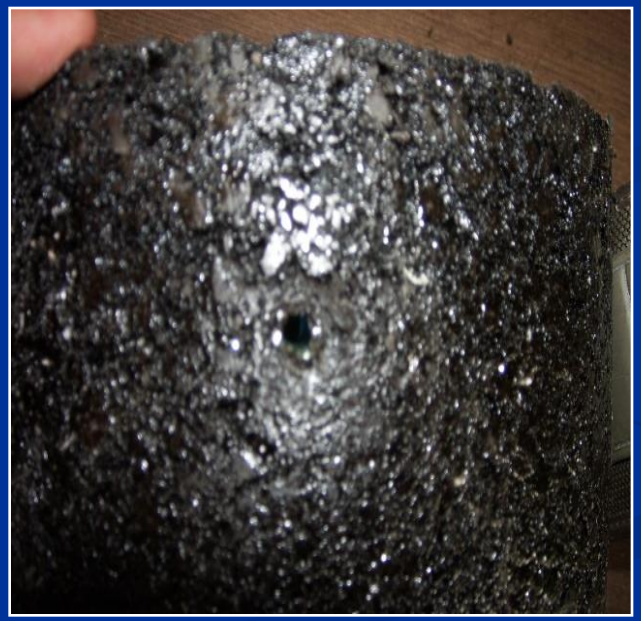
- Considering the stability of the pavement structure, minimum 6mm diameter has been chosen.

- Although the structural stability with 6mm pipe was not evaluated in the present study, we plan to do it in the near future.

## 2.3 Stability Evaluation of Installation and Heat Resistance of Pipe

- To simulate the field installation, 8mm depth U-shape groove was made.
- Mixture of aggregates of less than nominal size 8mm (90% Calcium) and cutback (10% MS) was refilled.
- 5 cm (2 in.) Hot Mix Asphalt of Maximum 200 ℃ was placed as surface (wearing) course using rotational compactor with 600MPa vertical pressure and 75 rotation.



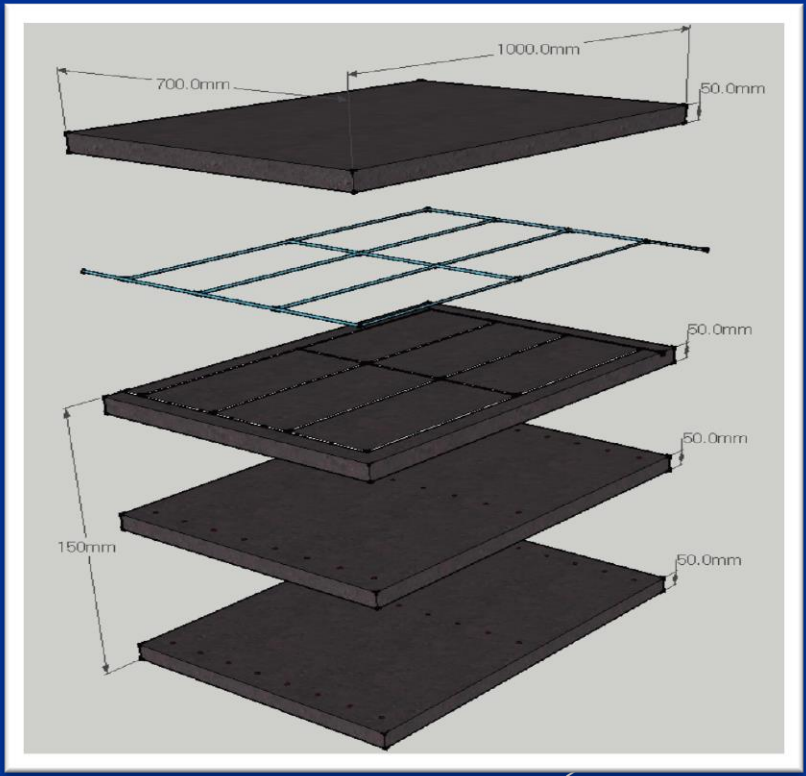



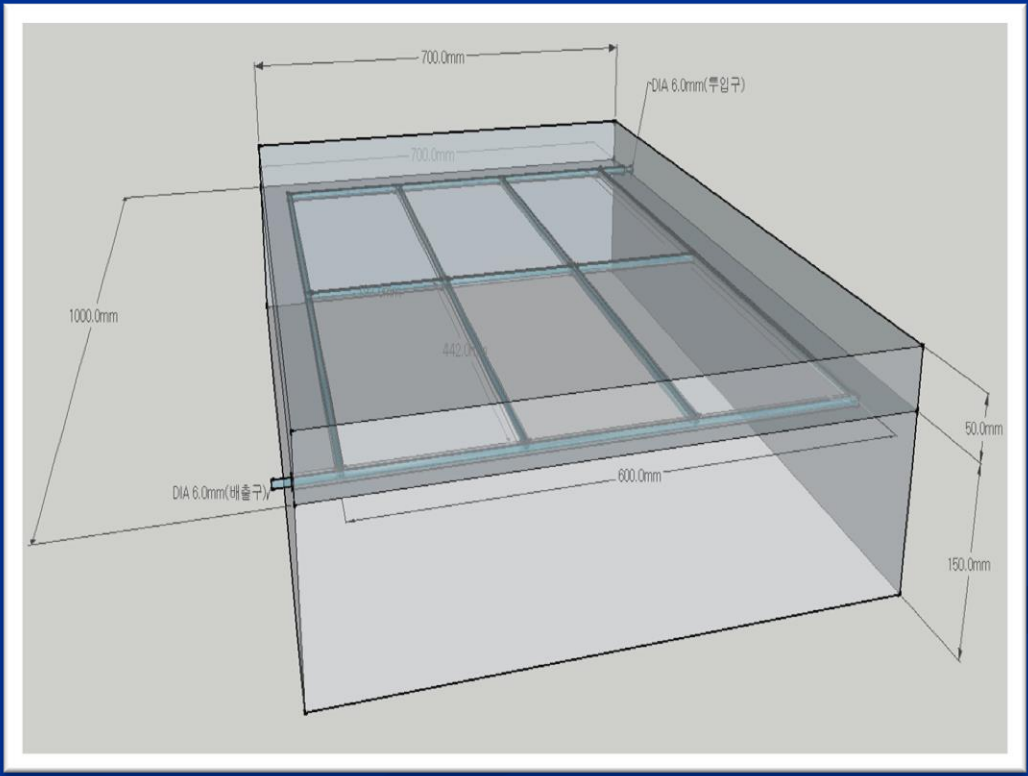
❖ It was confirmed that there was no deformation due to temperature and pressure when the TEFLON pipe was installed in the U-shape groove.

# 2.4 Development of a Proto-type Model with High Heat Transfer Pipe

◆ An Indoor Model was developed to extract heat absorbed by asphalt pavement and/or to circulate hot water to provide optimum temperature in the structure.

◆ Four layers of 5cm each were compacted to make total 20cm system. Twenty one sensors were installed in each layer.



# 2.4 Development of a Proto-type Model (Cont'd)

<Steps of Proto-type Model Construction>

## 2.5 Simulated Solar Heating System

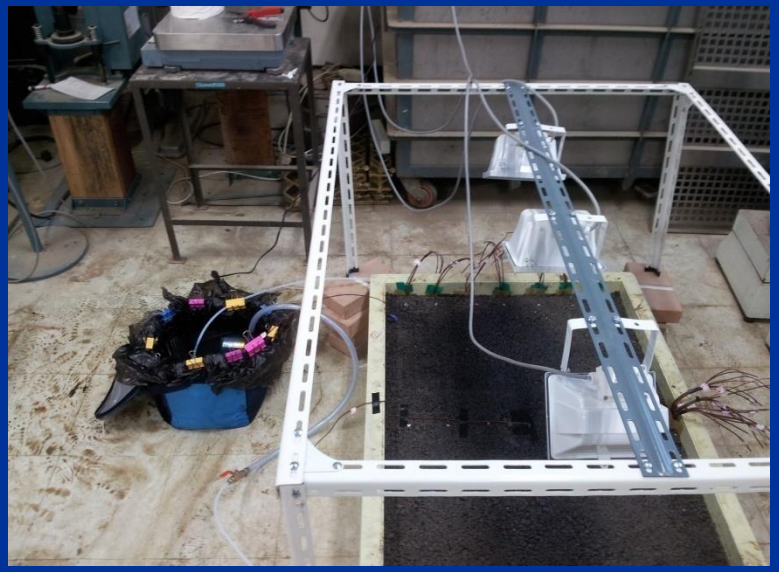
◆ Three 500W Halogen Lamps were installed 30cm~80cm above the pavement surface to simulate solar heating source.

◆ The simulated system was possible to adjust the lamp height and angle to control the temperature to be controled.

## 2.6 Water Circulation System Installation

- A maximum 8Liter/min pump was used to circulate the water through Teflon pipe embedded 5 cm below the surface. A monitoring system was developed to measure temperatures of water inside the Teflon pipe and each layer of the pavement every 10 minutes.

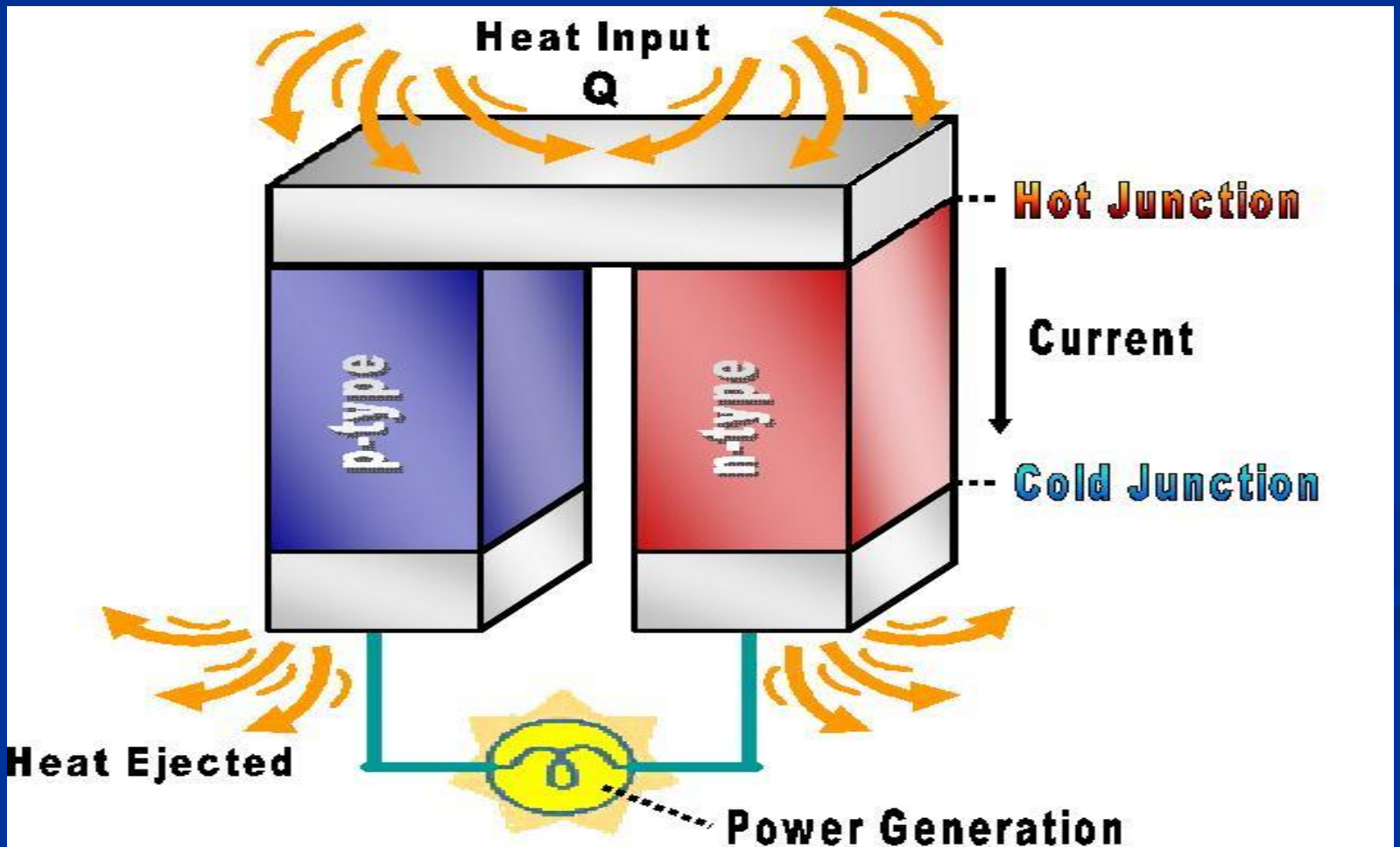
- The water flow (q) of 0.7Liter/min was used in the present study.



# (4) Thermoelectric Material Method

- Seebeck effect has been seen as a way to generate heat for the interiors of automobiles, with common commercial devices using p-type and n-type semiconductors

* Thermoelectric devices can be designed with enough voltage (1-3 volts) to store and convert solar energy to electricity in rechargeable batteries through utilizing the seebeck effect

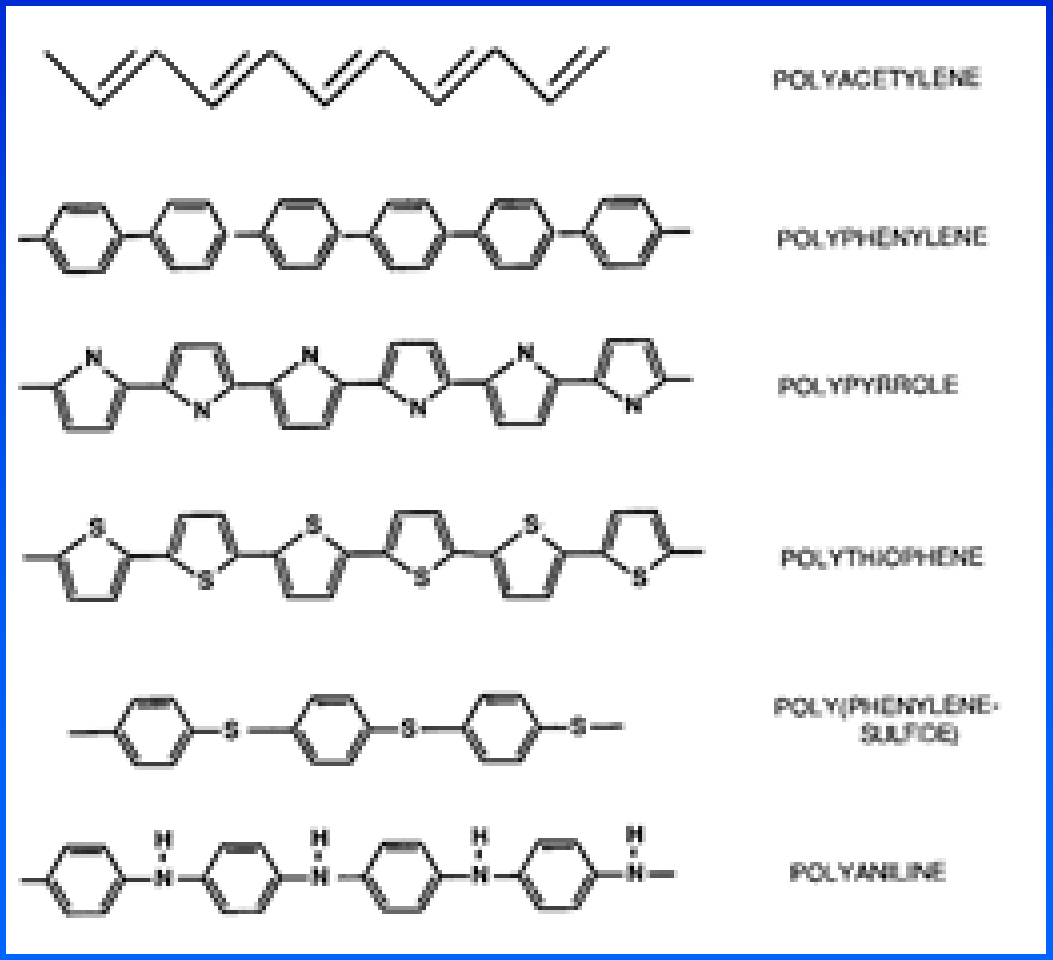


- Research has shown that there is a way to use organic semiconductors as a potential low cost material for solar energy conversion

- These organic materials have the potential for high power efficiency and are inexpensive to manufacture

- Efficiency for these semiconductors are proportional to the square of the Seeback coefficient, about 10 times higher than traditional metallic thermal couples

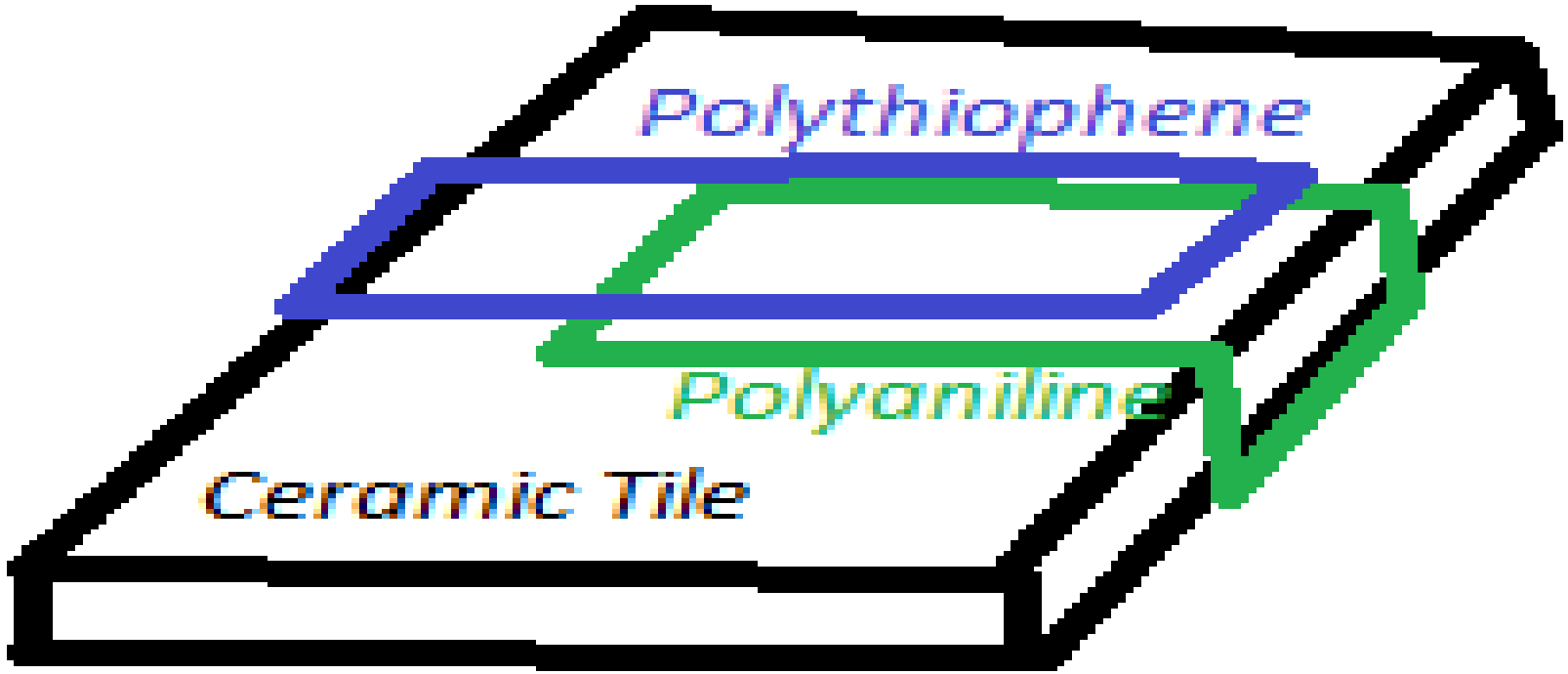
# Conjugated Polymers

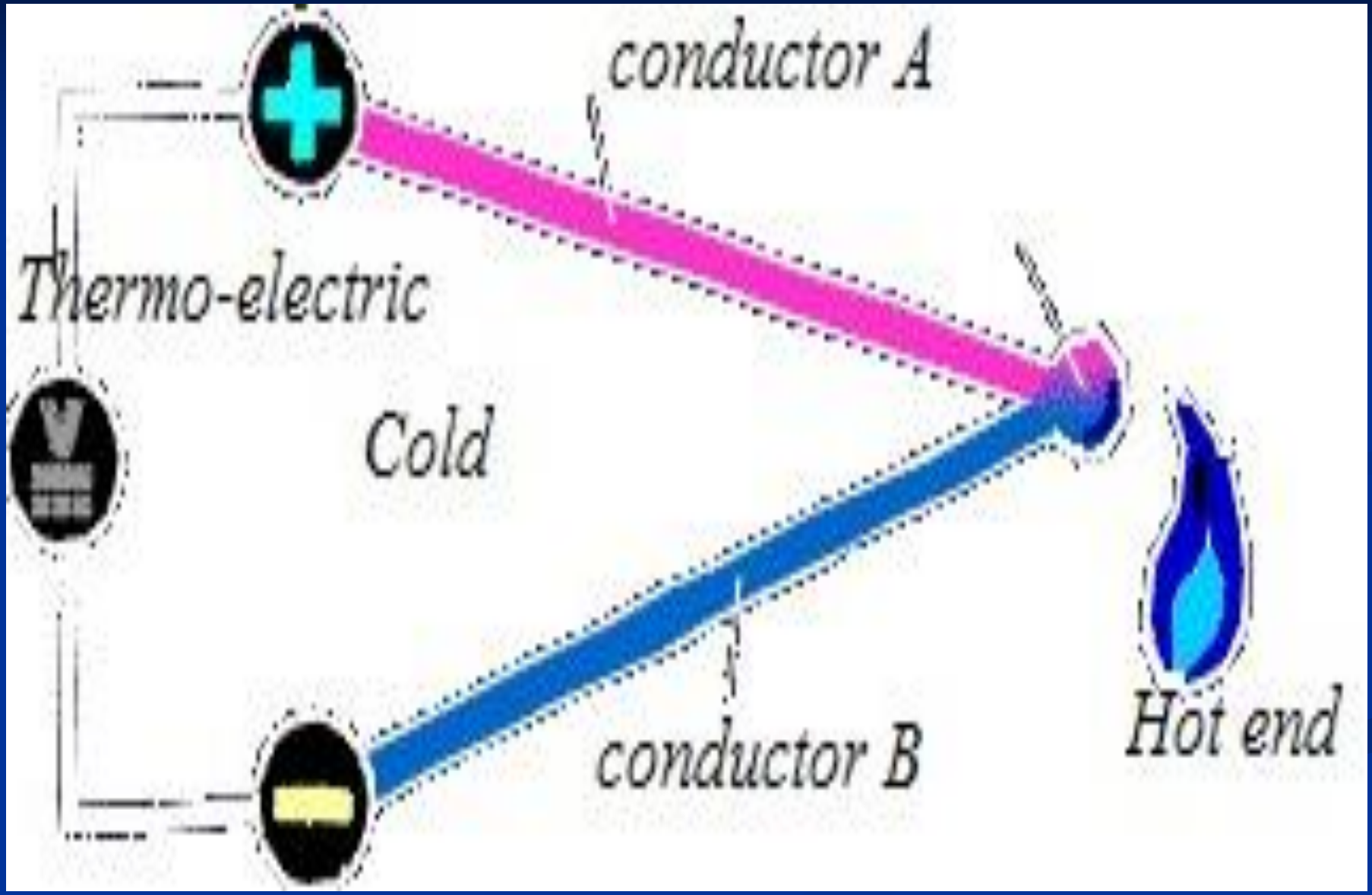


# Thermoelectric Material Method

- Organic semiconductor polymers were developed at URI for use as additives in paints for corrosion prevention of metals
- The challenge ahead is the development of multi-layer thin films or composite materials that will function as a thermoelectric device
- Integration of solar energy collected would be a function of the low cost process, where low cost materials must be considered

* To test these organic semiconducting polymers, a polymer film will be created to coat the surface of rooftops and pavements
* They can also be used within the building or asphalt materials as a blend: the development of future building materials could have these polymers integrated within them




conductor A
Thermo-electric
Cold
conductor B
Hot end

# Thank you
# and
# Happy New Year!

leew@egr.uri.edu

or

www.egr.uri.edu/ritrc