Controlling method for rain runoff from roof by green roofing

Kunihiro Ogihara

Dr. and Professor of Engineering

Department of Civil and Environmental Engineering

Toyo University

Kawagoe, Saitama, JAPAN

Abstract

Green-roofing in urban area of large city is focusing on the point of heat island phenomena as decreasing the temperature rise in summer season. New our green-roofing system has been developed in basic stage of research, and it has two advantages as decreasing the rain runoff and affecting to heat island phenomena to decrease the temperature rise.

In this green-roofing, wild plants in the area where roofing is settled are used, and the supplied water is used by the rain storage water. Almost of rain is storage in the tank on the roof and the water is used for supplying the plants and the amount of extra water is used for the second water supply instead of water from aqueduct. By this method, almost rain water is stored in the tank and only small amount of water runs off after the human using. So the runoff from the roof to river at the storm at urban area is controlled to be small and it has good effect to decrease the discharge of flood.

The observation in model green-roofing has been continued from August to December 2005, the effect of decreasing of the run off by this roofing system and also the effect of decreasing the temperature on roof surface can be shown in this paper. The observation in this model is continuing till June, 2007.

Purpose and Effect by this model

Generally the green roofing in Japan has an effect to decrease the temperature on roof surface about 20 degrees in summer season. This effect makes to decrease the energy for cooling the room in building in urban area. But almost the developed system uses the water from aqueduct for sprinkle water on plants or some cases uses the storage water of rain. In the latter case, storage tank is settled in underground or basement of building. These systems need the energy for pumping up water from storage tank to the roof and its energy is supplied from commercial electric system. So it spent the energy and the cost for water supply to green plants.

New system has an advantage to use the stored water of rain which stored tank is placed at roof and the sprinkle system is the intermitted dripped water supply system. So the energy for water supply is made by a smaller pump which is sufficient from the electricity from a solar panel.

And another advantage is the surplus water in tank which is stored by rain can be used for the others usage such as car washing etc. This system has two water tanks on the roof, an upper tank is for supplying the water to plants of green roofing and a lower tank is for storing the rain water. The capacity of storage tank for controlling the run off of rain from the roof is designed by considering the amount of sprinkle water for the plants at non storm condition and the amount of water for decreasing the water run off at storm condition,

Basic system of new green roofing

Basic part of new green roofing consists by a box which has soil layer, plants and water supply system. Plants for green roofing are used the natural weeds around the building, so genetic problem around the developed area does not arise. The basic model system is shown in figure 1, which is different from the prototype as the position of water tank and the capacity of water tanks.

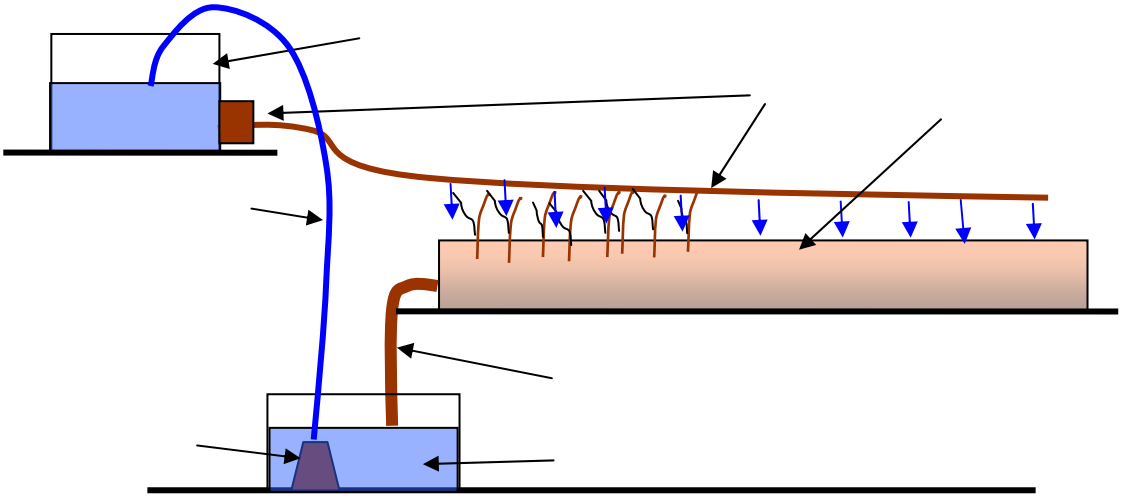

Fig. 1 The basic system for new green roofing

Upper tank, Water supply system by water drip, Box for green roofing, Hose from pump, Pump, Drainage hose, Lower tank

This system can be applied for parking area, median part of road and park by small boxes are placed side by side. Basic system is consist by plants box, lower water tank, upper water tank, pump system and sprinkle water system operated by timer which supplies water to plants by intermitted water drop.

Plants box has a capacity of stored water which can store the water corresponding that the rain intensity is under 30mm/hr. In the case of the rain over this intensity, water flows out from the plants box and stores in lower tank. The limit switch for pump is installed in upper water tank, and when the water level comes down after water supplies to plant box, pump in lower tank is operated for the water is pumped up from lower tank to upper tank. The height of pumped up is less than 1m, so the pump capacity is so small and the electric capacity for this become also so small. The electric supply system is sufficient by solar panel and so there is no need by commercial electric supply system.

Type of plants box

In basic type, the natural weeds around the building are constructed, but there are several types can be designed as rice field type, biotope type and lagoon type instead of natural weeds type. The natural weeds type has an advantage for genetic problem because plants are same around the building. And plants boxes are placed on the roof and water supply and drainage pipes are stetted with upper and lower tanks. Vegetable type is same as this type.

Biotope type has small ditches and small ponds in plants box and plants must be for wetlands. Water must supply continuously, so the water amount becomes larger and weight of total box becomes larger. But this type has small ponds and the flexibility for rain run off has advantage compare to another type.

In rice field type, every time there is water in depth of 3cm to 5cm in box and water level changes by rain condition. So only when the water level comes down less than 1cm, water is supplied from the tank. The amount of water becomes smaller than Biotope type.

In lagoon type, water level changes same as tide, so soil surface becomes under water and under sun shine by turns. This is effective to purified water but needs the control system for water level change.

All types are used the box and the size of box is 1m of the width and 2m of length and 15cm of depth, so has a good portability. On the roof, boxes are placed side by side in order to the size and form of plan of roof. So combination of several types can be arranged by one set of upper tank and lower tank is installed.

Drip type of water supply system is operated by gravity from upper tank and so it uses very small amount of water to compare the sprinkler system. So the pump for pumping up the water from lower tank to upper tank becomes smaller and its electric energy also becomes small. Only one solar panel is sufficient for this operating.

When natural weeds type is placed and solar system is used, the perfect maintenance free system can be constructed.

Observation model system

For getting the data as temperature changes and rain run off, two types of plant box are settled on the roof of building in Toyo University. One is natural weeds type and another is a tin roof. The apparatus for the measurements is shown in figure 2.

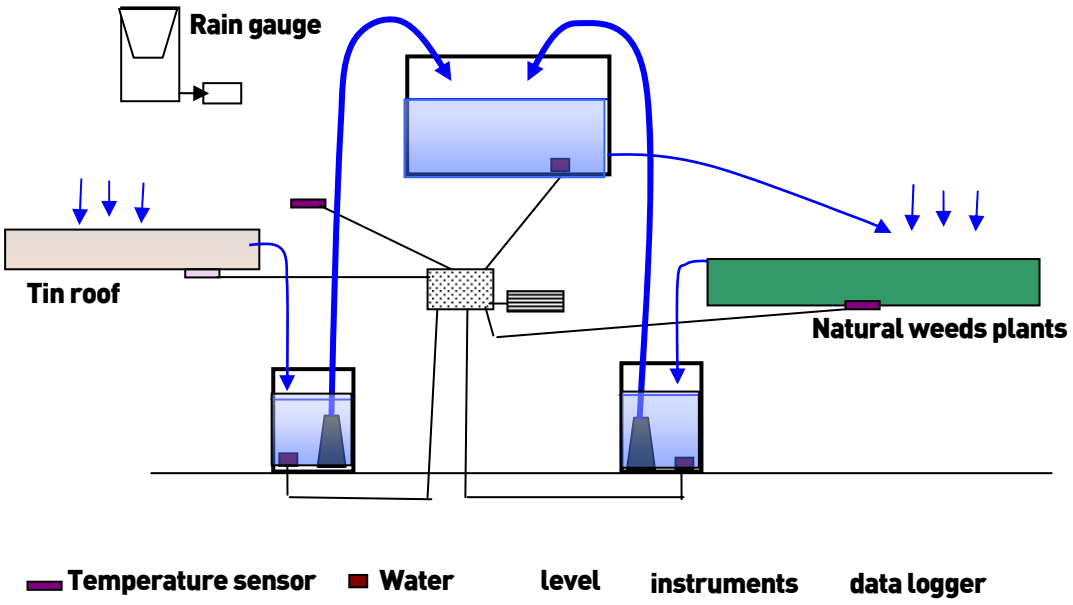

Figure 2 Apparatus and Sensor

There are three sensors for the temperature for atmosphere, the back side of two boxs and three sensors for water level changes to measure the water discharge from each box and in upper tank. The data are collected and recorded on the Pc card in every 5 min continuously from measurement instrument, and they are stored in data logger. The data from rain gauge is also collected in every 5 min. All these data are transferred to PC and calculation is made by Microsoft Excel.

Next two photos show the conditions of boxes just after setting, the covered by black sheet one is

upper tank. These two boxes are placed at higher place instead of on the roof, because polyethylene bucket which has 60cm height is used for the lower tank.

Photo 1 natural weeds type **Photo 2 tin roof type**

Two boxes are same size, because the catchments area is same for sun shine and rain. So the data can be compared directly each others.

Measurement method and analysis

The sensor for temperature is arranged at three points as atmosphere, the back side of each box. So effect of green roofing can be derived from the difference of temperature between atmosphere and back side of box.

Three water depth sensors are arranged at in two lower tanks and upper tank and the converted intensity of rain from plant box can be calculated from the record of the change of water level in the tank. And the difference of intensity of run off between plant box and tin roof box shows the effects by green roofing for rain run off.

All these data are collected at every 5 minuet continuously through September, 2005 to March, 2007. The method for collection is described in the before section and the following parameters can be derived from these data; converted intensity of rain run off from plant box, intensity of evaporation from plant box, amount of water supplied to drip the plant and the decreased temperature on the roof between plant box and tin roof.

Condition of plant growing

Weeds are planted at the middle of August, 2005 and watering by drip system has been made by 20 minuets lengths at 6 o'clock in both Morning and Evening. From the end of October, 2005, the interval has been changed to 10 minuets in every time.

The situations of plants growing are shown by photos as photo 3 to photo 5. The initial condition at the middle of August, 2005 is shown in photo 3, weeds are just growing. After one month in photo 4, weeds had many seeds and they dropped on the surface on plant box. And it can be expected that the new weeds will grow at next spring.

In photo 5, the weeds withered in winter and a little snow can be seen. The new weeds grow at April, 2006 as photo 6 and they can live in plant box till June, 2007. In these terms no fertilizer and no disinfectant have been done, so the situation becomes free maintenance.

Photo 1 weeds are just growing at 8,23,2005


Photo 2 they had seeds at 9,8,2005


Photo 3 they withered at 2,7,2006


Photo 4 they are growing again at 5,28,2006

Basic data of temperature

An example of record of temperature is shown in figure 3 from September 9 to 23, 2006. In this figure, there are four lines for atmosphere, at the back side of plant box and tin box and the difference between the one of two boxes.

The temperature at tin box shows higher than the one of atmosphere at noon and it becomes around 50 degrees of centigrade. But the temperature at plant box becomes 32 degrees at most high condition, so the difference becomes 18 degrees of max value.

It has a delay of about 3 hours from the change of atmosphere and tin roof. This comes from the difference of heat transmission between plant and soil layer and tin box. After collecting the more data of the temperature change at surface of boxes, and the data of energy of sun shine, the author can analyze the phenomena such as the heat transmission at plant surface and heat conduction in soil layer.

And the mechanism for heat island phenomena can be analyzed by collecting the data at this model green roofing through one year. Because the effects of green roofing on environmental conditions must be catch in both summer season and winter season

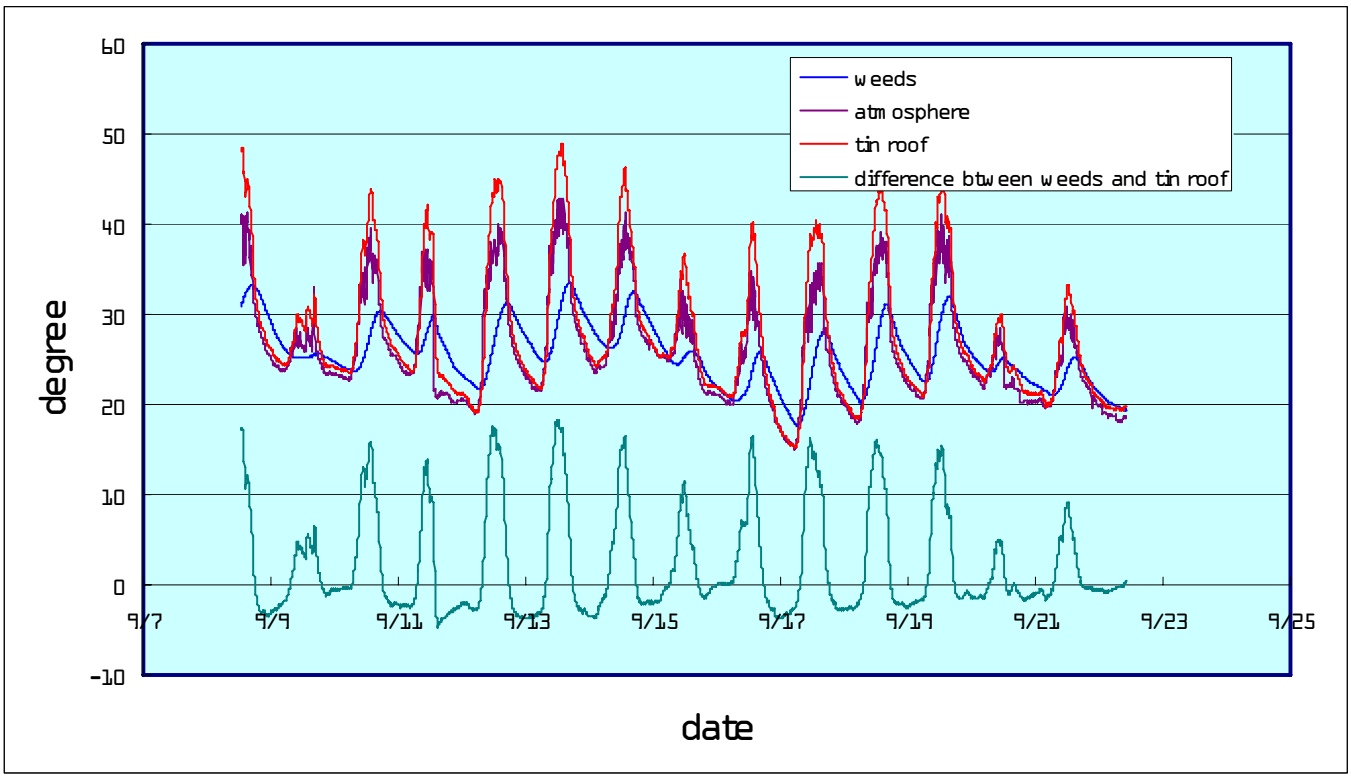

Figure 3 A record of temperature

Basic data of rain run off

Run off data are derived from the volume change which is calculated from the change of water level in the lower tank. An example of record is shown in figure 4 from October 13 to 20, 2005.

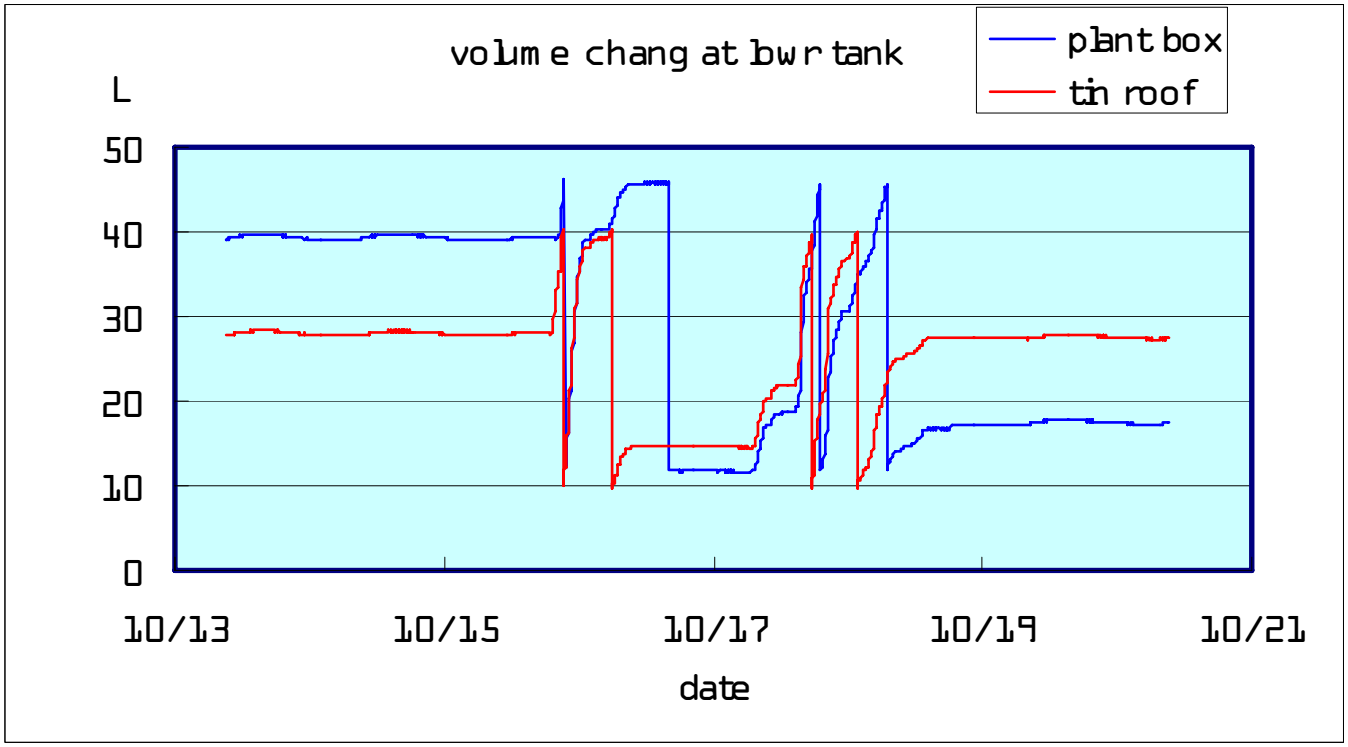

Figure 4 Record of water level change in lower tank

Water level changes by water supply when the run off occurs at rain from plant box to the storage tank. And pumping action occurs by limit switch acts on at high water position and switch off at low water position.

When water supplies to lower tank by rain and water level becomes higher limit, pump acts for pumping up the water from the lower tank to higher tank. So the curves vary up and down in this figure, as the water level comes down and the water level at upper tank rise up at pump is operated.

From the variation of water level at upper tank, the amount of water supply to plant box by drip system can calculated and finally the amount of evaporation can be derived from the difference of the sum of water supplied and drainage from the plant box.

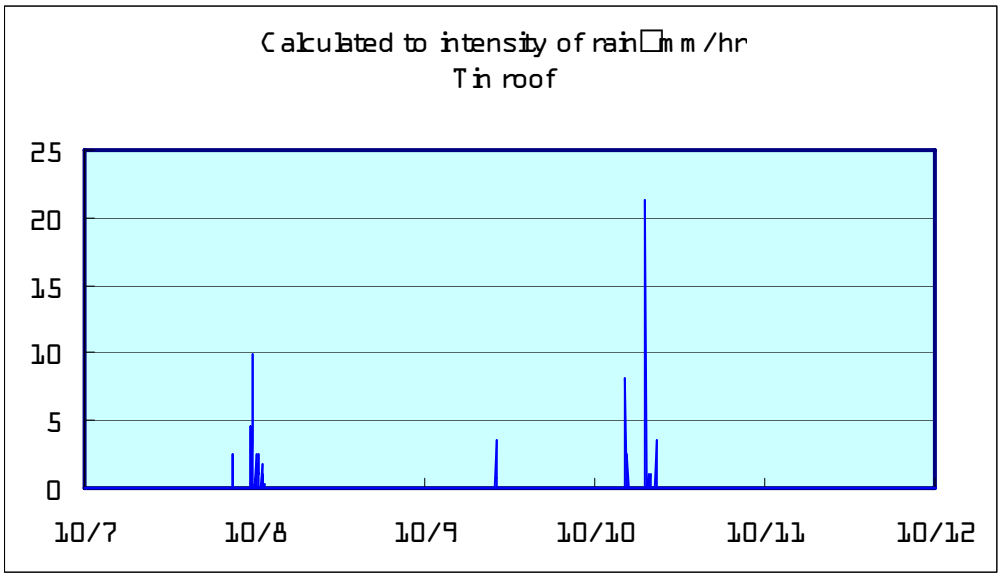

Figure 5 Calculated to Intensity of rain by Tin roof

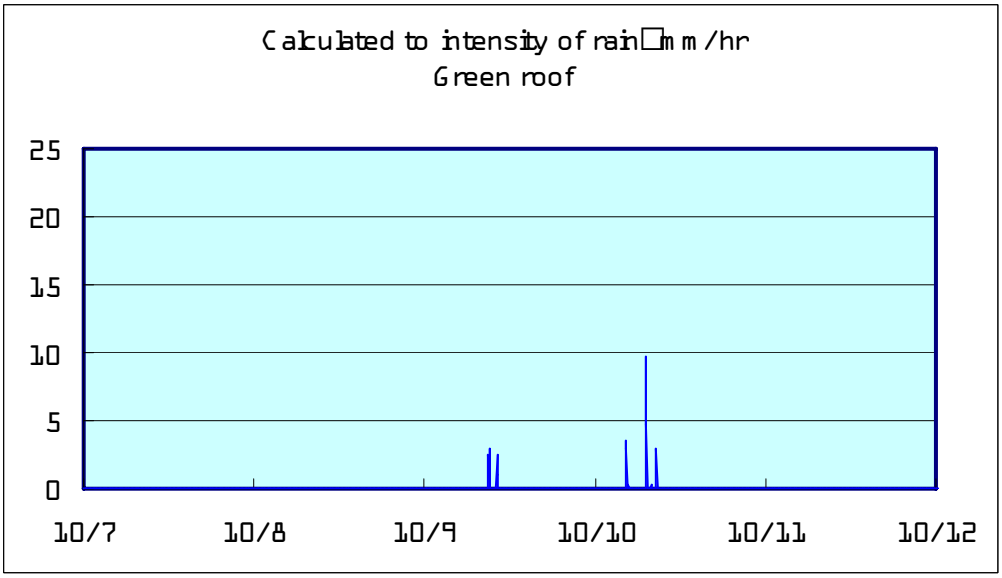

Figure 6 Calculated to Intensity of rain by Green roof

Calculated Intensity of Rain run off

The calculated intensity of rain run off is derived from the data of change of water level in lower tank. From figure 5 to 6, the comparison of intensity of rain can be done between each box and intensity of rain

meter.

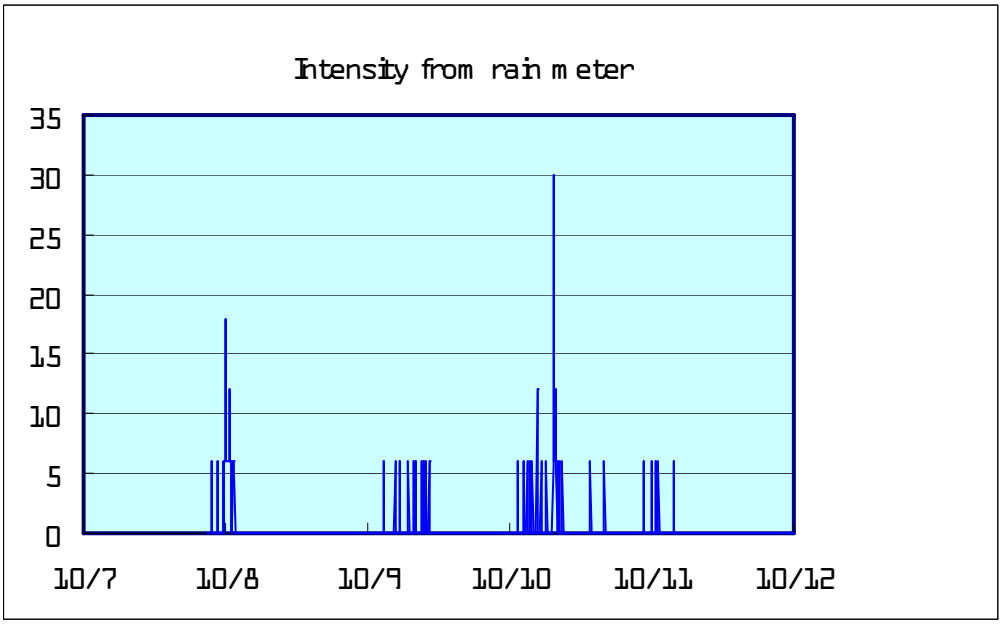

Figure 7 Intensity of rain from rain meter

There is large difference of water runoff between green roof and tin roof, as maximum value in October 10 is 10 mm/hr in green roof and 20 mm/hr in tin roof. The value of rain meter at this time shows 30mm/hr which is three times of green roof.

This means that the effect of green roof to the rain run off from the roof becomes from 1/2 to 1/3 decreases of rain.

Accumulated water by rain run off

The sum of water volume by rain run off from plant box and tin roof box from the beginning of September to the end of December in 2005 is shown in figure 8.

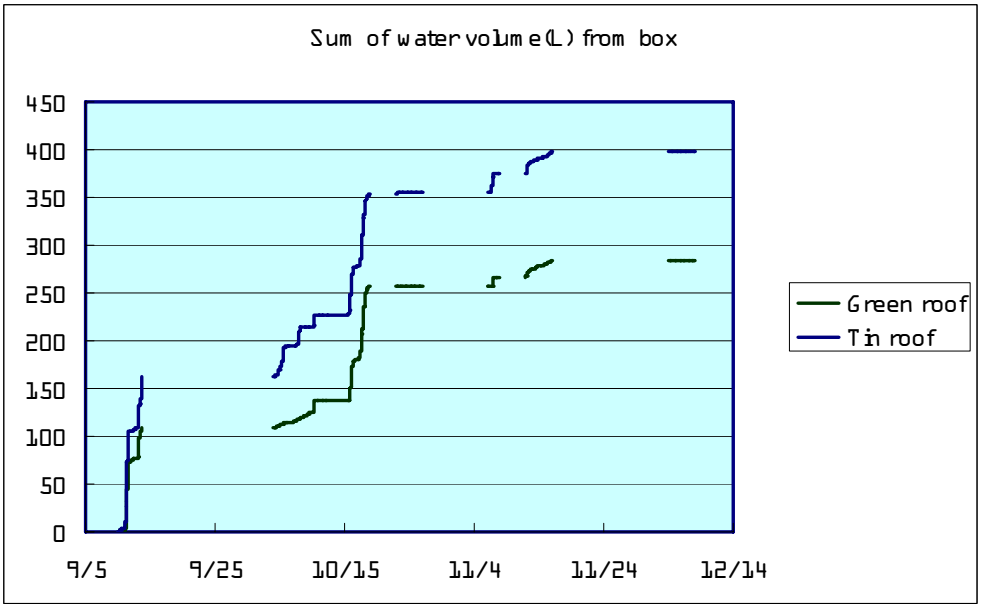

Figure 8 Sum of water volume by rain run off

The curves are plotted only rain was occurred. There is big difference as 400L from tin roof and 280L

from green roof. This means that cut of run off by green roof becomes 30% in green box itself. But this new green roof system has two other storage tanks as an upper one for dripping system and a lower one for storage of water, and so much more cut off of rain run off can be expected.

Supplied water to green roof box

The supplied water to green roof box can be calculated from the change of water level in the upper tank. Water for green plant is supplied by drip system in 20 minuets lengths at every 6 o'clock at morning and evening. The water level decreases by straight line in no rain condition, so the volume of supplied water can be derived from the inclination of straight line. The result of supplied water is shown in figure 9 as volume (L) in a day. The surface of soil layer in green roof has suitable humidity in these observations term.

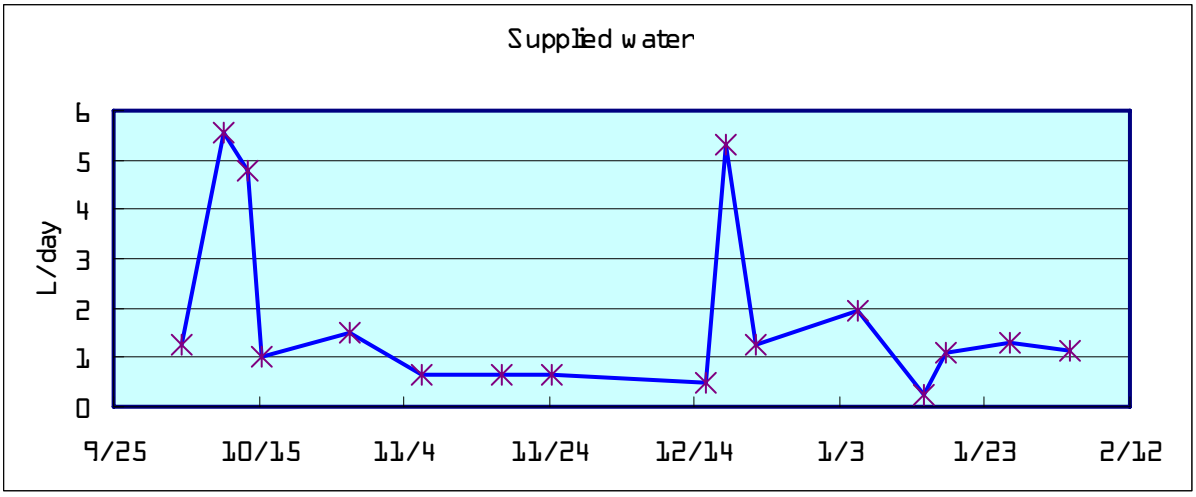

Figure 9 supplied water to green plant box

There is three large value points as 5 L/day in October and December 2005, but the value in the other term is 1 L/day. This difference comes from the condition of water surface in upper tank such as the water level becomes higher at the condition of 5L /day and the surface of water thatched to the roof of tank and the excess pressure acts on drip system. In the other conditions, the water surface becomes free surface condition. So usually the supplied water volume is sufficient by 1 L/day.

Evaporation

The evaporation from green roof can be derived the difference of water volume from run off between green roof and tin roof. The water volume which is not run off from green roof is the sum of evaporation from soil surface and the consumption by green plan. So it becomes 120 L between September to December 2005 as the difference the run off volume 400L from tin roof and 280 L from green roof.

And the supplied water for green plant in this term must be added except of rain, because this water volume is not running off from the box. The amount becomes the sum of water supply to this box, that is 89 L as the multiply of 1 L/day and 89 days. So the total volume of evaporation becomes 209 L (120 L+89 L). This means about 50% of rain water are evaporated from green roof and this affects good for temperature rise on roof and also good for heat islands phenomena.

Conclusion and research in next stage

The new system of green roof shows good results for the decreasing rain run off and decreasing the temperature on roof by analyzing the data collected from the small model. It shows 30% of cut for rain run off by green roof box itself; it is expected much more cut off by the combination of the other two tanks.

This system is developed by using the electric supply by solar panel instead of the commercial electric supply for controlling water supply system from April, 2006. So it becomes to add another advantage for consumption of energy and also the advantage to CO_2 problem.

Acknowledgments

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