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A New Design for Low Impact Development in Urban Area- Infiltration Pipe and Gravel Pile

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A New Design for Low Impact Development in Urban Area- Infiltration Pipe and Gravel Pile

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ABSTRACT

In this research, we utilized a small portion of any construction site in an urban area to enhance its infiltration for storm water. By using multi-units to spread the storm water runoff and restore the local hydrologic cycle. Based on the geological situation of Taichung City, which is mainly several thick gravel deposits underneath a thin layer of top soil with about one meter thick.

SWMM model was used to simulate the effect of installing infiltration pipe. Considering the amount of infiltration pipe and the reduction percentage of total runoff, the best configuration is changing interlock brick grass brick and installing infiltration pipe. In this scenario, 15% of surface runoff volume can be reduced under the 5 years return period rainfall.

KEY WORDS: Low Impact Development, Infiltration, Detention, Gravel pile, infiltration pipe, SWMM Model

INTRODUCTION

The annual rainfall is around 2500 mm, but 70% of the rainfall was fall in the wet season. Due to the urbanization in recent years, demand of land development was tend to be ever-increasing and caused the impermeable surface increase as will. It will reduce the opportunity of storm water to infiltrate. Moreover, pump out massive amount of groundwater to lower the water table for construction. These are the main reasons that bring about the ever-lowering water table in urban area.

So, we should take a more multivariate strategy on water resource conservation in downtown area. Thus, storm water treatment and run-off detention are essential to create the value of the rainfall water, not only use it as secondary domestic water but also use it to recharge the groundwater. There for we can achieve a more comprehensive hydrologic cycle too.

However, in the urban area, due to the cost of the land, it is very difficult to expand the drainage system or find a new location to build a detention pond.

Thus, it is lower risk and easer to conduct by utilized small construction to enhance the storage ability and infiltration rate in a limited area, and to speed up the recession process. In a series rainfall events, it can play an important role on reduce the run-off and to protect dwellers and their own property.

To consider with the possibility of pollution of the aquifer, these approaches should work with other LID unites to build a system that provided collection, depuration and reuse functions. This approach not only can reduces the pressure of the supply head, but also use the exceed water to recharged the groundwater. This study is aimed on develop system that combines storm water storage and infiltration approaches.

LECTURE REVIEW

Low Impact Development

Development of urban area usually changed the hydrologic behavior such as shorten the flow peak time and increase the runoff discharge. The low impact development approaches, however, could manipulate the influence of hydrologic in the situation of past development by set up infrastructures that can disperse the runoff, extend the runoff path and increase the flow concentration time to enhance the storm water retention amount of the lands.

Compared to conventional storm water management approaches, the LID techniques allow related water management authorities to control the run-off volume in the catchment. With these techniques, we could achieve the gold of dispersion of flood, by utilized the soil and planet, to enhance detention, infiltration, evaporation and filtration.

Infiltration Enhance Facilities

Conventionally, gravel pile approach was used to prevent soil liquefaction by take advantage of high conductivity of gravel pile.

Instead, by using character of high conductivity of gravel pile to penetrate the low infiltration layers, it can increase the conductivity and enhance the lateral infiltration rate as fig. 1 shows.

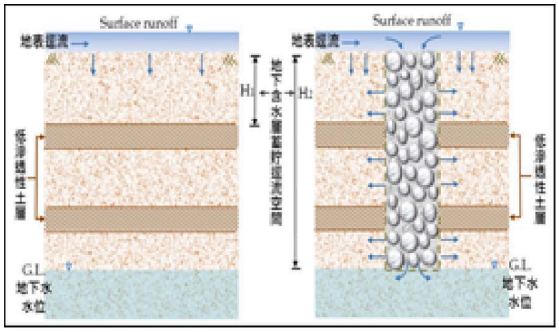

Fig. 1 Conceptual sketch of installing a vertical gravel pile

Infiltration pipe, is made by steel, deploy at the bottom of the permeable pavement. The rain full first collected by the pavement layer and through the pipe into the aquafer directly. Then the water infiltrate laterally from the holds on the sides of the pipe. This approach not only imports the surface water into the aquafer but also enhance the infiltration rate of the permeable pavement, the illustration of the permeable pavement combine infiltration pipe as fig. 2 shows.

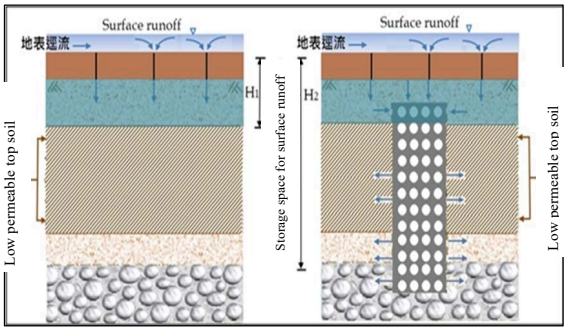

Fig. 2 Conceptual sketch of installing a vertical infiltration pipe

Study Area

The site of the bio-retention pond of the office building as fig. 3 shows, the storm water collected from the rooftop then discharge into the pond via a triangular weir to calculate the amount of flow. The pressure gauges were applying to measure and record the water level data. The storm water will infiltrate into the aquafer from the bottom of the pond.

Fig. 3 The experiment site of bio-retention pond next to office building

The experiment site of the infiltration pipe was inside the university campus, the site is combined three different types of brick pavement. According to its function, the structure of pavement was separate to two parts; the upper part is pavement and the sublayer is graded gravel servers as the foundation.

The upper layer brick pavement is made by same material, concrete, but the purpose and infiltration rate are all different, shows as fig.4; (A) drive way pavement is allow car to drive through, considering the load of car, the sublayer is use concrete to strengthen the foundation; (B) interlock brick pavement and (C) grass brick pavement are using in the parking area, so the sublayer is use graded gravel or sand as the foundation.

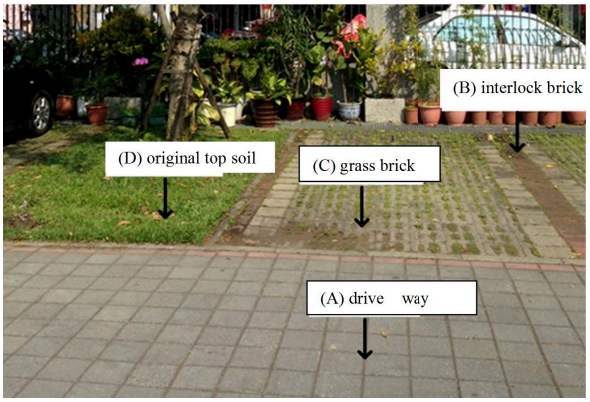

Fig. 4 different types of pavement of parking lot

Hydrologic Mmodel

To simulate the office building, the SWMM model had been conduct. The simulation was based on 1-day rainfall events of different return pried, the rainfall were collected by the roof of the office building and import into the bio-retention pond (impermeable). The conceptualize model of office building site shows as fig.5.

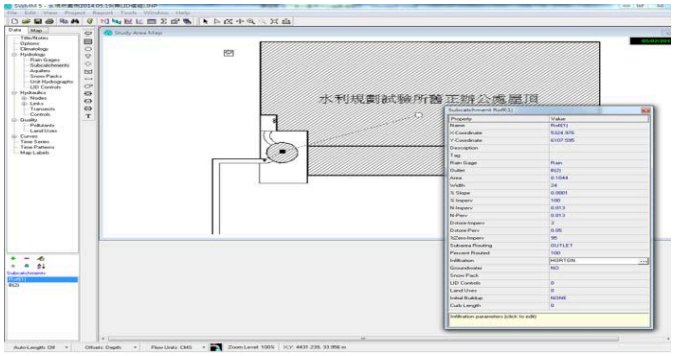

Fig. 5 the conceptualize model of office building site

Based on the surface condition of the parking lot conceptualize six sub-catchments. According to the slop of the parking lot and the observation of flow direction were used to set up the model. The conceptual model shows as fig. 6.

The model simplify by the surface type, S1 and S4 are interlock brick pavement, S2 is grassplot, S3 and S5 are grass brick pavement, S6 is drive way pavement and an outlet of overland flow. This study use the current condition as the basic condition to compared with other scenarios.

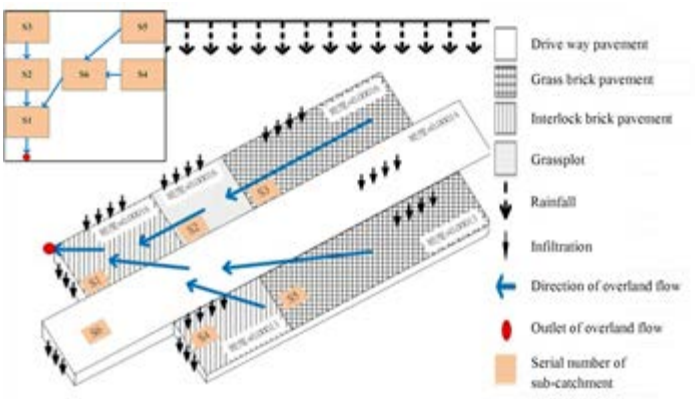

Fig. 6 the conceptualize model of the parking lot experiment site

Field Examination

The data collected from the artificial rain-full revealed that the original infiltration rate of the bio-retention pond was 24.7 cm/hr; after installed the gravel pile, the infiltration rate of the bio-retention pond increase to 477 cm/hr, the data shows as table 1.

By using experiment data and the rainfall event data to regress the formula then extend it into 24-hr as fig. 7 shows. The nature rainfall event, compared to the experiment data, the infiltration rate is approximately 10 times higher. The reason that the infiltration rate of experiment data was lower than nature rainfall event might because the water that have been infiltrate into the aquafer is more, the aquafer is close to situate.

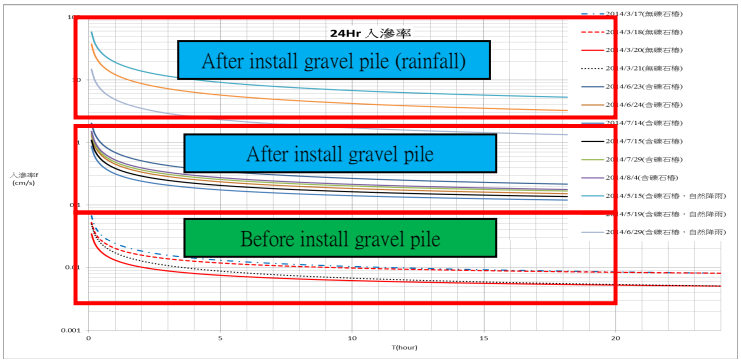

Fig. 7 24 hour infiltration condition of bio-retention pond in different context

Table 1 the infiltration rate of bio-retention pond w/ and w/o gravel pile

	before	after
Infiltration rate	24.7 cm/hr	477 cm/hr
Magnification	19.3	

The experiment data rearrange as table 2 shows, the saturated infiltration rate of interlock brick pavement with the infiltration pipe is 90.3 cm/hr, as fig. 8 shows the infiltration rate is 35 times higher than the current infiltration rate; the saturated infiltration rate of grass brick pavement with the infiltration pipe is 111 cm/hr, the infiltration rate is 18 times higher than the current infiltration rate. According to the results, the infiltration rate was significantly increases after the pipes were installed.

Table 2 the infiltration rate of inner ring before and after install infiltration pipe

	Interlock brick pavement	Grass brick pavement
original condition	2.63 cm/hr	6.31 cm/hr
after installing	92.5 cm/hr	113 cm/hr
Magnification	35	18

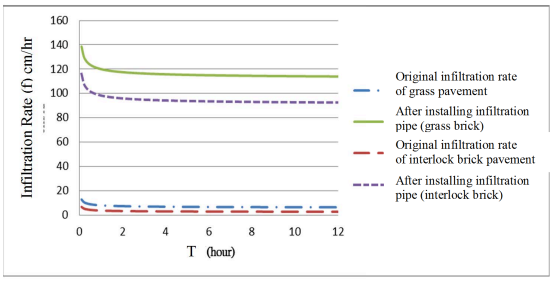

Fig. 8 the infiltration rate of interlock brick and grass brick with infiltration pipe

Results of SWMM Modeling

The bio-retention pond received the storm water collected from the roof top of the office building, the hydrograph of different return pried shows as fig.9. The runoff volume reduction are in the interval from 20.3% to 8.9% and the flow peak reduce percentage are in the interval from 6.25% to 3.59% under different circumstance.

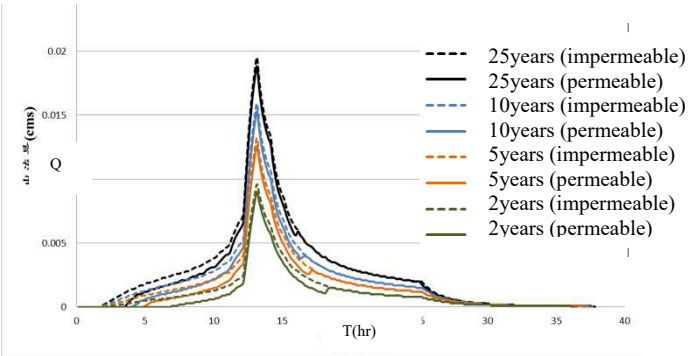

Fig. 9 simulation result of bio-retention pond in the office building site

The outflow amount of different set area of LID modal with grass brick pavement shows in the fig. 10. The outflow amount of different set area of LID modal with grass brick pavement and infiltration pipe as table 3 shows.

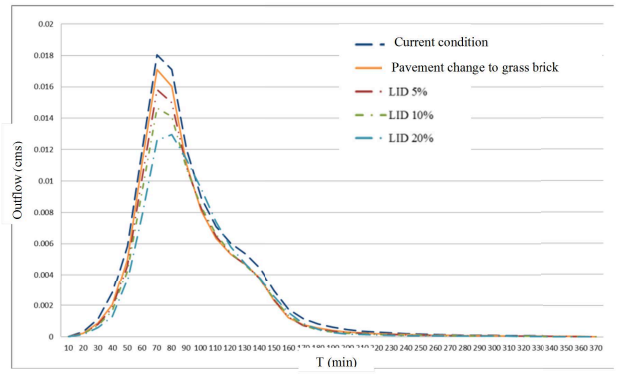

Fig. 10 hydrograph of altered the interlock brick pavement to grass brick pavement in the parking lot site

Table 3. performance of different LID model area of different context

	Current condition	Pavement change to grass brick	LID model			
			5%	10%	15%	20%
Infiltration pipes	--	--	118	583	1164	2320
Outflow volume (m^3)	1.11	0.99	0.948	0.912	0.894	0.844
Reduction (%)			4.4	8.5	10.7	11.9
peak flow discharge(m^3/s)	0.0180	0.0171	0.0158	0.0147	0.0136	0.0130
Reduction (%)	--	--	8.1	16.7	25.9	32

CONCLUSIONS

According to artificial recharge examination's results, it indicated that after installed gravel pile in a bio-retention pond, the infiltration rate was increased one order. And during nature rain full event, the infiltration rate was increased two orders.

Estimated the run-off reduction of the bio-retention pond by SWMM model, after the gravel pile installed in the bio-retention pond, it has been reducing 14% of the outflow volume and cutting off 5% of the peak of flow.

The parking lot, for instance, the infiltration rate of the permeable pavement with the infiltration pipe will enhance 18 to 35 times lager. Considering the amount of pipe and the runoff reduction percentage, the simulation result of the permeable pavement with the infiltration pipe shows the optima area rate is 10 percent of the original area; with the same alter area rate (10 percent of the original area), compared the interlock brick pavement to the grass brick pavement, the grass brick pavement could reduce 15% of the runoff volume in the 5-year return pried rainfall event.

These examples are just using a small area of the development area to evaluate the beneficial result of LID approaches, the results show that, in the small rain full situation, this approach provide considerable effect.

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