EVALUATION OF THE ROLE OF VEGETATION ON THE AIR QUALITY IN HIGH DENSE URBAN AREAS

Wai-Yin NG and Chi-Kwan CHAU

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR

INTRODUCTION

Massive building construction has become a byproduct of rapid urbanization in many metropolitan cities. Tree-planting campaigns are often launched with an objective to improve the environmental quality within urban cities. Despite so, there is some contradictory evidence showing that actual pollutant concentration level inside canyons would be higher if road traffic was found near to tree-plantings. We first validated our CFD models with the tree models in CODASC database [1].

Then, we aimed at examining the impact of vegetation on the pollutant dispersion in :

(1) Deep canyons (i.e. with aspect ratios higher than 2)

(2) Different green coverage canyons

Fig. 1 Typical street canyon with tree-planting in Hong Kong

METHODOLOGY

TERMINOLOGY

Aspect Ratio

$$\frac{Building\ Height\ (H)}{Road\ Width\ (W)}$$

Green Coverage

$$\frac{Area\ occupied\ by\ greenery\ _{(in\ xy\ plane)}}{Area\ of\ canyon_{(in\ xy\ plane)}}\ x\ 100\%$$

Normalized Pollutants conc.

$$C^{+} = \frac{c * u_H * H}{Q}$$

c is the mean pollutant concentration, u_H is the undisturbed flow velocity at building height H, Q is the emission source strength.

NUMERICAL SET-UP

- Series of three-dimensional CFD models have been preformed by FLUENT
- RANS approach with standard k-e turbulence model
- Tree canopy were modeled as a porous medium with pressure loss coefficient 200m^{-1}
- Pollutant source was modeled by Carbon Monoxide (CO) with emission rate 10gs^{-1}

MODEL

- Aspect Ratio : 1, 2 and 4
- Green Coverage : 0% , 12%, 25% and 50%

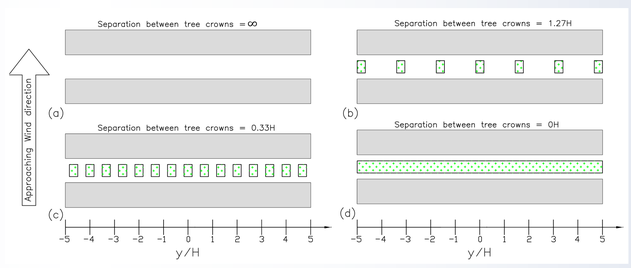

Fig.2 Sketches of the simulated street canyon models (Top view)

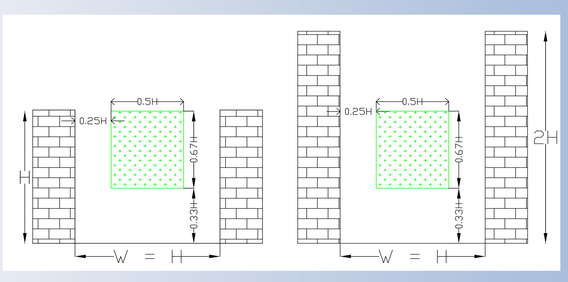

Fig.3 Cross-section sketches of the tree models in aspect ratio 1 (left) and 2 (right)

MAJOR FINDINGS AND DISCUSSION

Model Validation

Both simulated results of the concentration level and the dispersion pattern were in good agreement with the wind tunnel results obtained from CODASC [1].

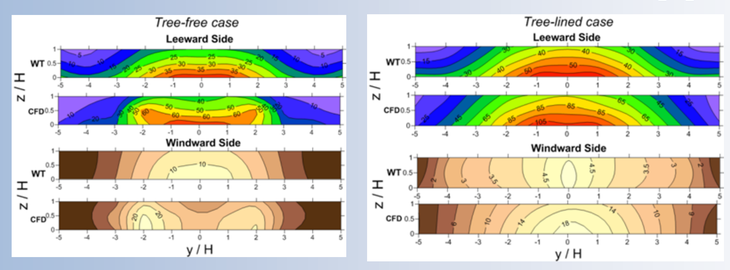

Fig. 4 Contour plots in the tree-free and tree-lined case

Tree-planting under different canyon geometries

Aspect Ratio	1			2			4		
	Tree-free	Tree-lined	Δ C	Tree-free	Tree-lined	Δ C	Tree-free	Tree-lined	Δ C
Leeward side	33.80	60.17	+78%	27.05	43.58	+61%	34.51	59.06	+71%
Windward side	15.85	10.49	-34%	65.22	46.77	-28%	42.50	60.74	+43%
Pedestrian zone	37.57	51.98	+38%	94.01	129.88	+38%	243.75	310.50	+27%

- Tree-planting leads to an overall **increment** of the pollutants concentration in different canyon geometries
- Under Aspect Ratio 1 & 2 , concentration level increases at leeward side while the concentration at windward side decreases
- Under Aspect Ratio 4, concentration level increases at both sides as the tree canopies obstructed the upward dispersion flow

Effect of green coverage within the canyons

- Different green coverage scenarios modeled by increasing the separation between trees
- All tree-lined cases have higher concentration level than the tree-free cases
- Higher pollutant concentration is found in the pedestrian zone of the trees lined canyon with spacing between trees (i.e. 12% and 25% green coverage cases)
- Maximum concentration level occurs at 25% green coverage

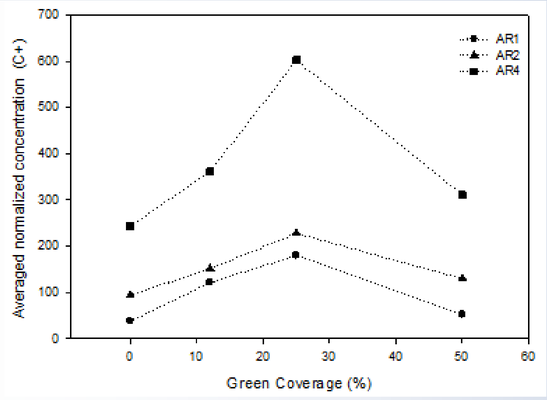

Fig. 5 Concentration profile in different green coverage scenarios

CONCLUSION

The aerodynamic effect of the street level tree-planting should not be overlooked. Urban planner should strike a good balance between the positive effect on the temperature reduction, energy saving and the negative effect on the air quality of the vegetation. Trees are not recommended to plant along the centerline on the street canyon as trees may obstruct the pollutants dispersion process.

Reference:

[1] CODASC Database, 2008: Concentration Data of Street Canyon, internet database, http://www.codasc.de.