Executive summary

ES1. Introduction

In July 2009, the Drainage Services Department (DSD) provided a grant to the author of the University of Hong Kong to conduct a scientific *Study of Climbing Plant Species for Application of Vertical Greening in DSD Facilities*. The field research used the external walls of four large sludge tanks situated at the Shatin Sewage Treatment Works. Installation of the green wall, initial vegetation establishment and testing of environmental monitoring equipment were completed at the end of May 2010. Twenty climber species selected after comprehensive review of the scientific literature were tested in three experiments. Influence of selected site factors was evaluated. Live data collection started from 01 June 2010, originally scheduled to last 28 months. The DSD subsequently requested a 12-month extension of the monitoring to end in December 2012.

ES2. Study objectives

The four objectives of the study were:

(a) To carry out a review based on published literature on the selection of climber plant species and to identify suitable species for planting on wall surfaces;
(b) To monitor the cooling effect of the vegetated walls in the humid-subtropical condition of Hong Kong using a combination of field temperature sensors and data loggers;
(c) To design and implement a vertical greening trial at the Shatin Sewage Treatment Works; and
(d) To evaluate the performance of selected climber plant species in relation to some pertinent growth parameters, such as aspect, climber supporting mechanism, growth medium, and horticultural maintenance.

ES3. Deliverables

The project anticipated the following deliverables:

(a) Selection, evaluation, acquisition, installation, testing and maintenance of scientific monitoring equipment;
(b) Regular collection of data and data analysis;
(c) Interim reports and presentation of interim results;
(d) Final study report; and
(e) Seminar to present the research findings and recommendations.

ES4. Organization of the report

This report presents the findings and practical recommendations of the study in the following chapters:

(a) Introduction
(b) Study area and method
(c) Experiment I: Site factor effect
(d) Experiment II: Climber species performance
(e) Experiment III: Cooling effect
(f) Practical recommendations and conclusion

ES5. Site factor effect and recommendations

Mesh mode verified to be better than concrete mode

The mesh climbing mode is superior to concrete with reference to establishment rate, growth rate, growth height, growth density, gaps between stems, and overall climber performance index. The mesh mode is recommended where appropriate for future green walls. The concrete mode has the advantage of minimum capital cost, and can be adopted where fast greening is not expected and the budget cannot afford installation of the mesh training system.

Replaced soil verified to be better than original soil

The replaced soil prepared according to a dedicated soil specification, with reference to mineral composition and amendment with mature compost and slow-release fertilizer, registered better climber growth performance than the original soil. This expenditure on soil improvement is one-off, and is not particularly expensive in relation to the total project cost. It is recommended that future green wall design can include replacement of site soil with an improved soil mix. The replaced soil should be managed in the long term to sustain its qualities.

Orientation verified to be notable determinant of climber growth

Due to the geographical location of Hong Kong in the northern edge of the tropical zone, the south orientation receives more direct sunshine in all four seasons. The tested climber species were not stressed by the enhanced solar radiation input at the south walls which offers the best aspect for vertical greening. The east and west walls receiving less but adequate direct sunshine are the second best for climbers. The north side suffers from inadequate sunlight for plant growth. If there is a choice of walls with different orientations, the above order of preference could inform the decision.

ES6. Climber species performance and recommendations

Objective assessment of climber performance

The performance of the 20 tested climber species was assessed based on detailed data collected in the field over the 30-month monitoring period. Five plant growth attributes, including establishment rate, growth rate, growth density in the lower half and upper half, and flower attractiveness and quantity, were selected to compute an integrated climber performance score. The scores were then converted into five literal grades ranging from the top-ranking A to E to offer a succinct yardstick for future selection of climber species in green wall works.

Preference for A and B grade climber species

The mesh climbers with A to C grades perform notably better than the concrete ones with B to E grades. Three A-grade species from the mesh group are strongly recommended for future use: *Quisqualis indica*, *Wisteria sinensis* and *Lonicera japonica.* Three B-grade mesh climbers can also be recommended: *Antigonon leptopus*, *Bauhinia corymbosa*, and *Bougainvillea spp*. The only B-grade climber in the concrete group, *Parthenocissus dalzielii,* can be used on bare walls for fast and cost-effective greening.

Conditions for the use of C to E grade species

The C-grade species that suffer from slow establishment and growth rate can be used where fast greening effect is not demanded and site conditions are less exposed. The site conditions should match the species innate needs especially with regard to sunshine and shading. The D- and E-grade species should be used with full understanding of their limitations and with application of ameliorative measures to mitigate them.

ES7. Cooling effect of green walls

Cooling effect in summer

Cooling of vegetation surface is more prominent on summer sunny day due to absorption of latent heat of vaporization in the process of transpiration. It indicates that a portion of the incident solar energy has been used beneficially to cool rather than to heat up plant tissues. The east and south sides which receive more solar radiation have better cooling. The cooling effect on west side has been reduced due to shading by the pump station. Irrigation has helped to sustain water supply and hence maintained transpiration cooling. Summer cloudy day with reduced direct sunshine has subdued cooling effect. On summer rainy day, cooling of climber surface is attributed to continual washing by rainwater which drains the heat from plant tissues.

Cooling effect in winter

Cooling effect in winter is evidently weaker on sunny, cloudy and rainy days. The thermal behaviour on the winter sunny day differs markedly from the summer equivalent. Again the south orientation has brought the best cooling benefit. On winter days, solar energy again has been used to cool rather than to heat up plant tissues. It is notable that maximum cooling in occurs in nighttime or early morning on the cloudy and rainy days when solar radiation input in daytime is limited. In contrast, the summer days always have maximum cooling in daytime.

ES8. Cooling effect of behind the mesh climbers

Cooling effect behind the mesh-climber in summer

The behind-mesh concrete surface is consistently cooler than the control concrete surface in all summer weather scenarios. This cooling is brought by the combination of shading and transpiration cooling by plant leaves. It indicates that the cooled concrete surface behind the living vegetation on the mesh transmits less heat into the indoor air lying behind the wall. It can bring cooler and more comfortable indoor environment, and reduced consumption of air-conditioning electricity in summer months. The resulting cooling can offer long-term on-site and upstream environmental benefits.

Cooling effect behind the mesh-climber in winter

The winter finding is the opposite of summer. The behind-mesh concrete surface is consistently warmer than the control concrete surface under all winter weather scenarios. It indicates shielding of the wall from the elements by climbers on the mesh. This finding indicates retention of heat in the concrete materials shielded by living plant tissues on the mesh. The retained heat can be transmitted to the indoor air lying behind the wall to usher warmth. It can improve human comfort in the indoor environment and be regarded as another prominent season-specific environmental benefit.