Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
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Journal of Applied Sciences 13 (11): 1960-1964, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.1960.1964

Green Thought on the Design of Chinese College Dormitory

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Abstract: In order to improve thermal environment of dormitory and amend the disadvantages in the dormitory, this paper introduces some green though to the design of Chinese college dormitory from two aspects: bettering the outdoor environments and optimum the dormitory design. Furthermore, the paper proposes some methods for the green dormitory design that are simple and effective for architects.

Key words: Dormitory, green though, outdoor-environments, design

INTRODUCTION

The dormitory provides students a place where the student can study and live in and the indoor environments will influence students' physical and mental health and efficiency of study. The paper introduces green thought to the college students' dormitory project in China in order that architects design a comfortable and green dormitory. Furthermore the paper puts forward some green though on the planning and design of college students' dormitory.

RESPECT ENVIRONMENT: GETTING COMFORTABLE OUTDOOR MICROCLIMATE

The outdoor microclimate effect the indoor environment through many ways. So it is important to better the outdoor microclimate of dormitory. There are some factors needed to be considered: climate, site, the feeling of people and interrelate of them (Luo *et al*., 2005). The planning of college students dwelling district should consider firstly the climate of site and take into account the living and psychical demand of students on outdoor-environment. The direction, form, spacing and height of building group and the design of road and planting will affect the microclimate in college students dwelling district and the sunshine and ventilation of dormitory and energy consumption of dormitory. In order to get better outdoor-environment some measure will be adopted.

Respect the pristine land feature. The plant cover in pristine site is important resource of improve the microclimate in students dwelling district. The surface soil is related to the growth of plant, so the design of planting should depend firstly on the surface soil. Moreover, if there is water surface in site, it is advantaged to outdoor-environment and the panning of college dwelling district (Lv, 2003).

Choose dormitory face depended on the change of local sunshine. Sunshine owns directional properties, so different orientations of building obtain different radiant quantity. Except the roof the other vertical faces get radiant quantity according to season and orientation (Fig. 1). It can be known form the figure that in winter the south face get the most radiant quantity and in summer the east and west faces get the most radiant quantity (Lin and Zhang, 2000). So the southing is advantageous in heat preservation in winter and thermal insulation in summer. Therefore during the planning of college students dwelling district the building orientation must be taken into account.

Arrange dormitories according to the outdoor wind field. The outdoor wind field affects directly the indoor natural ventilation of dormitories. In summer it is better that the dormitories face the dominant wind direction in favor of the indoor thermal environment; in winter it is advantageous for dormitory to avoid the dominant wind direction.

Do feasible planting design. Plant cover has many important functions: reducing air temperature, adjusting air humidity, weakening sunshine, decelerating wind speed, improving air quality, shadowing noise and nocuous ray, ameliorate the thermal feature of enclosing construction and absorb dust and nocuous gas. Furthermore the water mass can cleanse water and reduce the reflection of sunshine. The design of planting is very important to the planning of students dwelling district and architects should plan college dwelling district as following methods:

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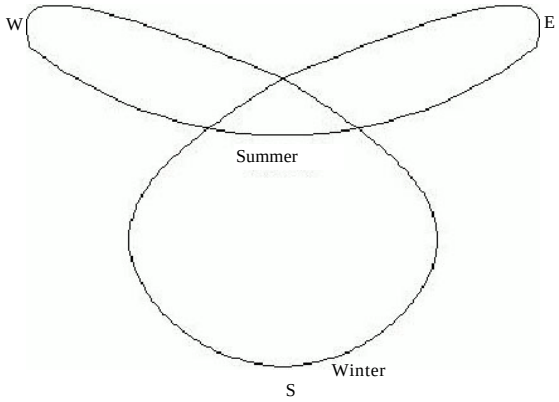

Fig. 1: Directional properties of sunshine

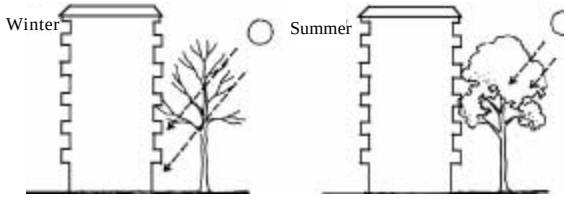

Fig. 2: The broadleaf arbor affect dorm indoor environment

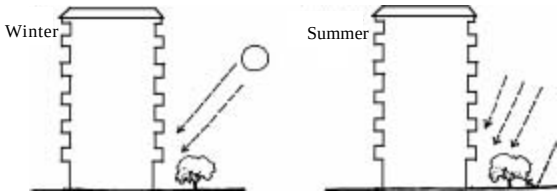

Fig. 3: The shrub improve dorm indoor environment

- The planning of students dwelling district on the one hand ensure the field of building, on the other hand use as much area to planting as possible
- Pay attention to the quality of planting: (1) to try to protect the inherent greenbelt and tree and to be used indirectly or moved, (2) to plant the native tree or grass because they have adapted to local nature and need less maintenance, (3) to consider fully the lighting ventilation shadowing and landscaping
- Unite the planting and the local climate (Sophia and Stefan, 2000). The broadleaf arbor can provide enough shade in summer and avoid weakening sunshine in winter in college students dwelling district (Fig. 2). And the evergreen in space cavity at northwest of dormitory shapes barriers preventing cold wind (Fig. 3). Some dense planting equals to a wall of obstructing wind. The green brattice sheet has the function of weakening wing in large-scale and avoids air vortex in the leeward of building. Even the hardwood also can weaken the wind speed in winter (Fig. 4)
- Plant in roof and wall space (Xia, 2012). 1) Planting in west and east wall. Boston ivy at the face of wall in east and west can drop effectively the indoor temperature in summer. The data of actual measurement show that the temperature of room with Boston ivy at the face of wall drops 7°C and the humidity of it increases 10%, moreover the dust and noise are absorbed. (2) Planting in roof. The plant in roof reduces the gain of quantity of heat to enclosing construction and improves the indoor thermal environment with the plant's functions of shading rising and photosynthesis. The Table 1 shows different effects on indoor thermal temperature in different roofs. On the other hand the roof can be taken as an entertainment place where students enjoy the cool in evenfall in summer and bathe in sunlight in winter. And the plating in roof will enrich the form of building

Table 1: Different effects on indoor thermal temperature in different roofs

	Ventilation roof	Planting roof with earth	Planting roof without earth
Inner surface temperature of roof (max.) °C	35.5	30.8	30.9
Inner surface temperature of roof (average) °C	31.6	29.5	29.8
Outdoor air temperature (max.) °C	34.8	34.8	34.8
Outdoor air temperature (average) °C	29.5	29.5	29.5

COMFORTABLE AND ENERGY-SAVING: GREEN THOUGHT ON BUILDING DESIGN

With logical architecture composition:

- The room kind of student dormitory is simpler and less and it is composed of dorm, assistant room and stair hall. In a project of dormitory it is important to make thermal partition. The room of dorm needs the best thermal environment so that it should be arrangement in better orientation and district. In addition it is better to place the water closet or some assistant room in which is near head wall with worse thermal environment. And the stair hall should be arranged as possible in north side in dormitory (Baruch, 1998)
- Improve the ventilation in dormitory with the chimney effectiveness of stair hall. In summer the chimney effectiveness of stair hall should be reinforced in order to obtain better indoor ventilation; in winter the chimney effectiveness of stair hall

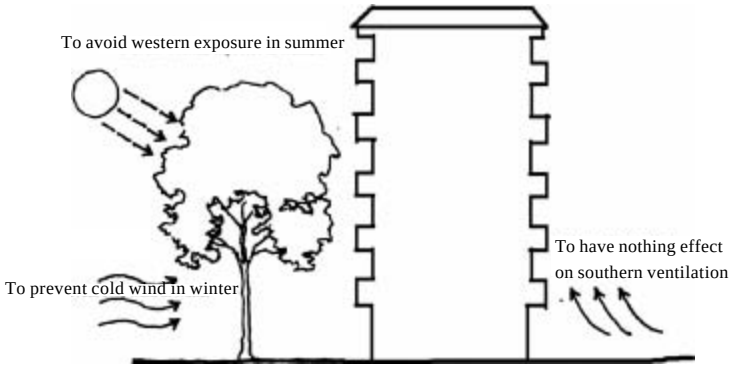

Fig. 4: The planting and wind in the northwest of dormitory

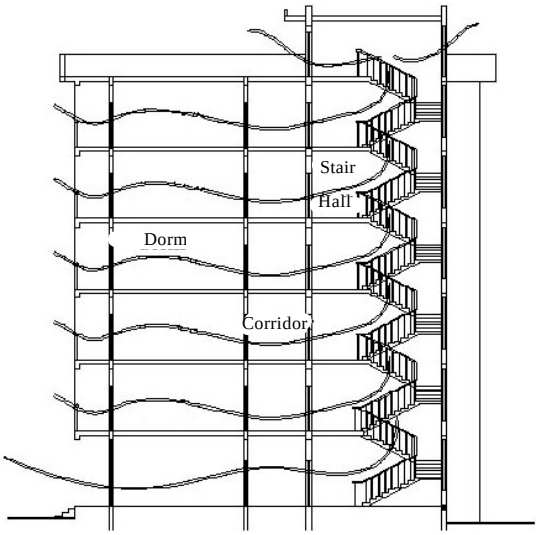

Fig. 5: Improve ventilation with stair hall

should be avoided in order to reduce the loss of heat quality indoors (Song, 2003). There are three means (Fig. 5), (1) to change the two-run stair to three-run stair in order to make vertical space for ventilation, (2) to arrange partition door in stair hall that in summer keep open for the sake of reducing the resistance force of ventilation and in winter keep close as possible for weakening ventilation, (3) to render the roof of stair hall in dark color for the reason of reinforcing ventilation by the thermal pressure in summer and having less effect on indoor ventilation because of less intensity of radiation in winter

Design of enclosing construction: Enclosing construction as the outer wear of building has important functions of reducing the unpleasant effect from outdoor and creating comfortable indoor thermal environment:

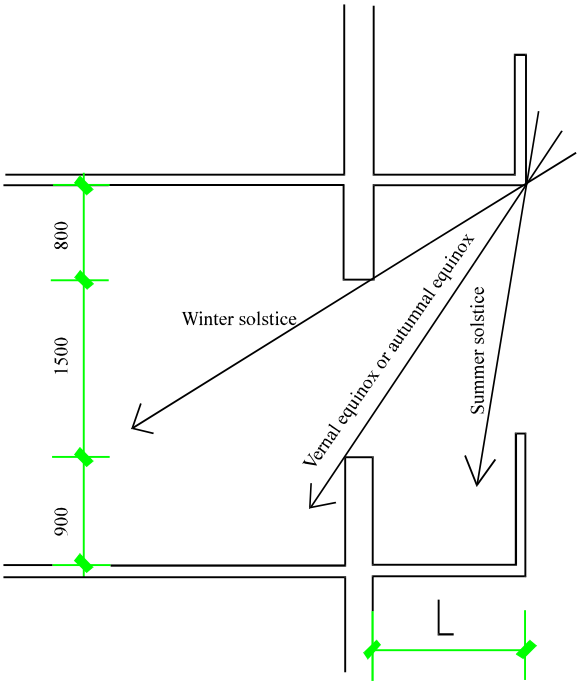

Fig. 6: Ideal distance that balconies project from exterior wall

- Enforce the thermal insulating function of exterior wall (Zhang and Yin, 2012). In China the exterior wall of dormitory is at large solid brick wall which is enough in load bearing and lack in building insulating. As a result it should be taken place by new wall material and construction that is lower heat transmission coefficient, higher quality of load bearing, advantageous in aseismic design and easy to job. To dormitory is better to use cavity brick taking place the solid brick. In some area the building insulating construction should be taken in dormitory. The better place of construction of heat

insulating is outside of main wall in dormitory. Moreover the walls with different orientations should take different measure of heat insulating in order to optimize the cost of insulating material because the walls with different orientations gain different quantity of sunshine, especially, the south wall gains the most quantity of sunshine; by contraries, the north wall gets the least. As a result the reward from adding heat insulating construction is different and the reward of north wall is more than it of south wall and the reward of west wall and east wall is between it of north and south wall. Thereby it is beneficial to take different quantity of heating insulting in walls with different orientations and it is obvious to enhance the effecting of heat insulting in the wall with higher validity heat transmission coefficient, especially the north wall

- Design doors and windows. The doors and windows which is one of the basic construction components has the functions of ventilation, lighting and heat insulating that affect the indoor environment. But the doors and windows is the weakest part to heat insulating in building. The data show that the heat loss form common doors and windows is almost two of thirds of the all loss from building, in which the loss from doors and windows by conductance is about one of third and the loss from the blank in doors and windows is one of third. Thereby, it is very important for improving indoor environment and saving energy to choose proper proportion between the area of doors and windows and the area of exterior wall and reinforce the doors and windows capability in heat insulting and pressure tightness (Xia, 2012). (1) To control the area of windows. It is an extremely complicated multidimensional optimizing problem to choose the area of windows in exterior wall that provide comfortable indoor thermal environment and light environment and reduce the cost of energy. It relates to the climate, the orientation of dormitory, the construction of exterior wall, the windows feature of thermal and light, the students' demand of thermal and light and so on. The beat way is enlarging properly the area of south windows and reducing relatively the area of north windows on the condition of having nothing influence on ventilation. (2) To lessen the infiltrate of cold air from windows. The useful way is to enhance the pressure tightness. The windows of dormitory are aluminum alloy sliding windows which have lower pressure tightness because of making, transport and setting. If the aluminum alloy sliding windows (its quantity of air infiltrate is 2.5 m3 $m \cdot h^{-1}$) are taken place by aluminum alloy casement windows (its quantity of air infiltrate is 0.5 m3 $m \cdot h^{-1}$), in which the loss by infiltrate reduce 80%. Furthermore the type of windows should be shorter length of seam, less ratio between the perimeter and the area and larger proportion between the area of glass and the area of windows.

Design of balcony:

- Take the balcony as thermal buffer zone. Thermal buffer zone is transient region between the room requiring better thermal environments and outdoor in order to gain better thermal in main room. The buffer zone as heat break reduces not only 40~50% the loss by thermal transmission but also the loss by infiltration of cold air. In cold area, the balcony of dormitory can be thermal buffer zone by changing un-close balcony to close one

Close balcony that is generally designed in dwelling house has functions of adding area and space, security and preventing sand blown by wind. The close balcony in dormitory not only adds the area of building use but also brings down the indoor degree of dust which improves the indoor air quality. In cold area close balcony help to raise the indoor air temperature which extent depend on the climate because the close balcony reduces greatly the cold air infiltration from outdoor. Especially, the south close balcony acts as green house in the daytime which effect on indoor thermal environment to a great extent.

- Use balcony's function of sunshade. Dormitory's balconies that project some distance from exterior wall have function of sunshade in summer. But the distance that project from exterior wall is got by calculation in order that the balconies have nothing influence on indoor sunshine in winter. The ideal distance is showed in Fig. 6 (the line in the figure means solar altitude angles), which shade the sunshine to south windows between vernal equinox and autumnal equinox and ensure enough sunshine in winter. The ideal distance can be calculated by formula 1. For example, in Xi'an the solar altitude angle at noon is 32.25° and the L is 1.27 m (approximately 1.3 m) which can ensure the sunshine radiating directly into dorm at noon of winter solstice by formula 1. If L is 1.3 m sunshine can radiate directly the window ledge when the solar declination is 4.46° which means the time between April 7th and September 7th every year when sunshine cannot

radiate directly into south dorm. It is logical that south balconies project 1.3 m from exterior wall, in which improves the dorm indoor thermal environment and satisfies the demand of use:

$$L = H \cdot \coth_s \cdot \cos\gamma_{s,w} \quad (1)$$

where, L is the ideal distance (meter), H is the height from underside edge of balcony to upside edge of window (meter) h_s is solar altitude angles (degree), $\gamma_{s,w}$is the difference between the solar azimuth angles and wall azimuth angles (degree)

CONCLUSION

- Architects can improve the inner thermal environment of dormitory by creating a mild and comfortable outdoor micro-climate. Architects should plan reasonably the college dwelling district depend on the local geography factors and climate factors such as solar radiation and wind. On another hand, architects also consider the planting in college dwelling district. It is important to improve greening coverage and decide greening configuration according to the local climate
- Architects can better the inner thermal environment of dormitory by some passive design methods that are convenience effective and inexpensive such as reasonable layout, heat preservation of building envelope and design of balcony

ACKNOWLEDGMENT

This study was financially supported by the Special Fund for Basic Scientific Research of Central Colleges, Chang'an University (CHD2012JC081) and the Natural Science Foundation of China (51178050).

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