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# Effect of insulation ground on anti-condensation in rural residence

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**Abstract**

Condensation on ground often occurring in rural residence in hot and humidity area is a threat against its indoor thermal comfort. This paper studies the moisture-proof measures on ground in rural residence in Chongqing area. A typical two-story rural residence was modelled by using DesignBuilder software. The data of annual ground temperature and humidity which were used to calculate the duration and strength of condensation in cases of using ordinary residential cement ground and thermal insulation ground was simulated. The results show that: for Chongqing rural residence, the temperature of the first floor is generally lower 1-2 degrees than that of the second floor; The ground condensation of rural residence in Chongqing area are mainly concentrated from the end of March to early July; the effect of thermal insulation ground to avoid condensation is good to solve the problems occurred in rural residence, when the insulation layer thickness is 50mm and the thermal resistance value is 0.49m2 - K / W, it can basically eliminate the ground condensation.

Peer-review under responsibility of the organizing committee iHBE 2016.

*Keywords:* Rural residences; Ground condensation; Moisture-proof measures; Thermal resistance

## 1.Introduction

Chongqing is in Southwest China, due to the perennial high wet climate condition, indoor ground condensation problem is very serious, and concentrate on March to July[1]. It is particularly important to solve the problem of indoor ground condensation. At present, residents take some measures such as thermal insulation ground to solve the problem, but these measures are not clear and have no specific construction parameters. At the same time, Chongqing rural residence ground has good storage performance of heat and cool during the summer and winter which can effectively regulate the indoor air temperature. The anti-condensation measures will affect the advantages. This paper search for such a critical thermal insulation layered thickness, which can give full play to the advantages of rural residences ground that warming in winter and cooling in summer, and prevent ground condensation effectively.


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## 2. Research methods and model establishment

### *2.1Research methods*

A rural two-story residential building in Chongqing was selected as research object, residential building model was established by DesignBuilder software. By using the typical meteorological year data of Chongqing from the Standard Chinese Meteorological Database[2], annual indoor temperature, humidity and surface temperature of the typical rural residence were simulated. On the basis of the calculation methods presented in the literatures[3], the total number of dew hours could be calculated. According to the data, the ground dewing time and strength, and the improvement to dewing by using moisture-proof measures were analyzed.

### *2.2model establishment and settings*

Figure 1 was a simplified model of rural residence established by using DesignBuilder software, figure 2 was the plan of the first floor. Building envelope thermal parameters were set depending on the actual construction of the building envelope, as shown in table 1.

Building ground was set to 2 kinds of circumstances, respectively for ordinary cement ground, thermal insulation ground. The cement ground was used commonly in Chongqing rural residences, the structure was that concrete and cement mortar layers covered on rammed earth layer. For thermal insulation ground, the insulation layer material was full lightweight aggregate concrete. Thickness variation range was from 10mm to 100mm. The specific parameters of the 2 kinds of ground were set in table 2.

Five months were selected from March to July to simulate, and two types of ground surface condensations were analyzed. The construction models calculated based on the monthly mean temperature of Chongqing underground 0.5 meter. In the internal heat source settings, the internal heat and mechanical heat source were setting at 4.3 W/m$^2$ depending on the 50824-2013 GBT 《Rural residential building energy efficiency design standards》 [4]. From March to July, indoor window opening and natural ventilation all the days were set.

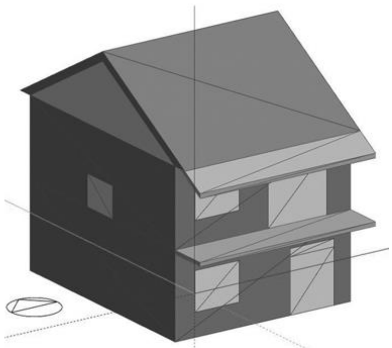


Fig.1. The two-story residential building model

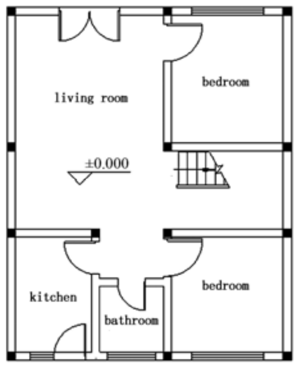



Fig.2 Plan of the first floor

**Building envelope construction parameters** **Table 1**

| structure | Construction layer(from outer to inner ) | Coefficient of heat transfer W/(m$^2$·K) |
|---|---|---|
| External wall | 20 mm paint<br>240 mm perforated brick<br>20 mm paint | 1.5 |
| Roof | 25 mm roof tiles<br>The attic ventilation layer<br>50 mm cement mortar<br>180 mm aerated concrete<br>120 mm concrete | 0.8（sections under the ventilation layers ） |

| | | |
|---|---|---|
| Internal wall | 20 mm paint<br>120 mm perforated brick<br>20 mm paint | 2.1 |
| floor | 20mm cement mortar<br>100 mm concrete<br>20 mm paint | 3.0 |
| External window | — | kicthen3.2<br>bathroom4.7 |
| External door | — | 3.0 |

**Three kinds of ground construction parameters** **Table 2**

| Ground type | Structural parameters (top-down) | thermal resistance （$m^2$·K/W） |
|---|---|---|
| Cement ground | 20mm cement mortar<br>100mm concrete | 0.29 |
| Thermal insulation ground | 20mm cement mortar<br>Lightweight concrete（0-100mm）<br>100mm concrete | 0.30—0.68 |

## 3. Simulation results analysis

### *3.1. Simulation analysis of ground temperature of the rural residential building*

Ground is a large heat storage body, the change of surface temperature is lagging behind the change of air temperature. Compared with the second floor, the temperature of the first floor was generally lower 1-2 degrees, as shown in Figure 3, from March to July, the ground released cooling radiation to the first floor indoor air, reducing the indoor temperature. Therefore, in summer, the first floor of rural residence is usually cooler than the second floor.

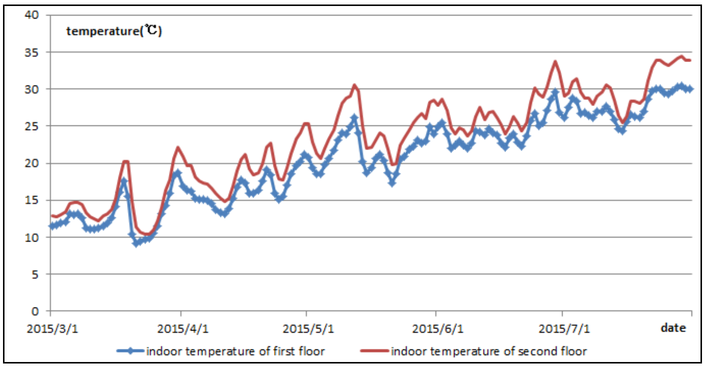



Fig.3. Contrast curve of indoor air temperature change between the first floor and the second floor of rural residence

### *3.2. Analysis of cement ground condensation situation*

Condensation on ground often occurring in rural residence in hot and humidity area is a threat against its indoor thermal comfort. According to earlier researches and the existing literatures, for rural areas in Chongqing, the condensation problem concentrated in wet season from March to July, this period was chosen to analyze the effects of condensation in environmental factors. Once the surface temperature is lower than the dew point temperature of indoor air, condensation phenomenon will appear. Figure 4 shows the relationship between the average daily temperature and the dew point temperature of the indoor air during March to July. From the late of March to early July, the ground temperatures were lower than the dew point temperatures, the ground showed continuous condensation. Until the end of July, there was nearly no condensation phenomenon.

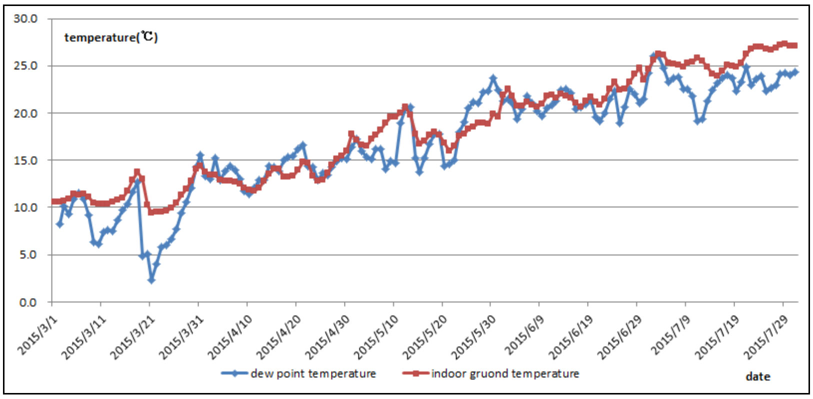



Fig.4. Contrast curve of indoor air dew point temperature and ground temperature of rural residence

In addition to simulation, the measure data of a rural residence by a research scholar named Ping Song was used to analysis. Depending on the literature[5]of the research scholar, the ground temperature and air temperature indoor hall were measured, and the dew point temperature and condensation hour was calculated. As shown in Figure 5 and 6, June 18-20 when the three days were rainy and June 26-28 when the three days were high temperature were chosen to measure by the research scholar:

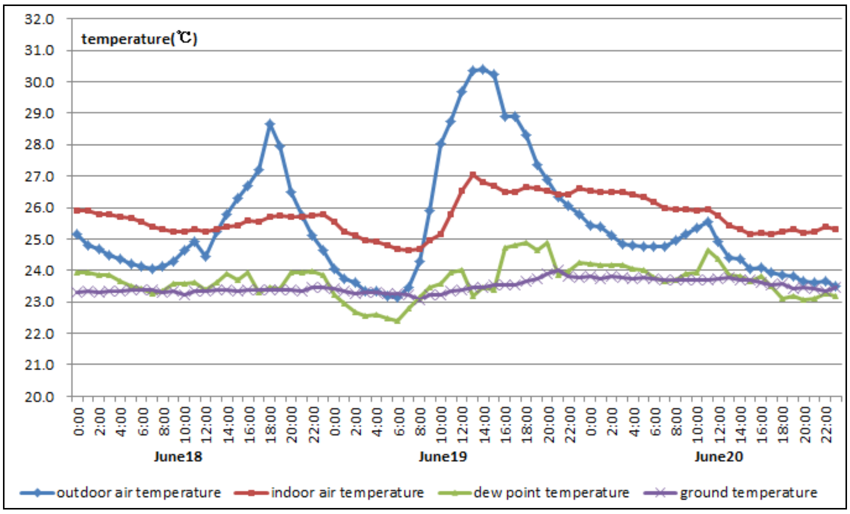



Fig.5. Relationship between indoor temperature and ground temperature from 18th to 20th in June

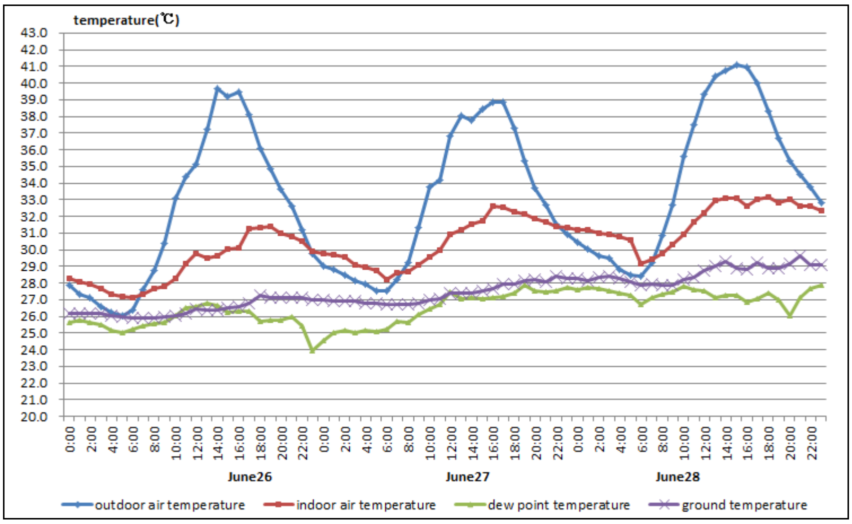
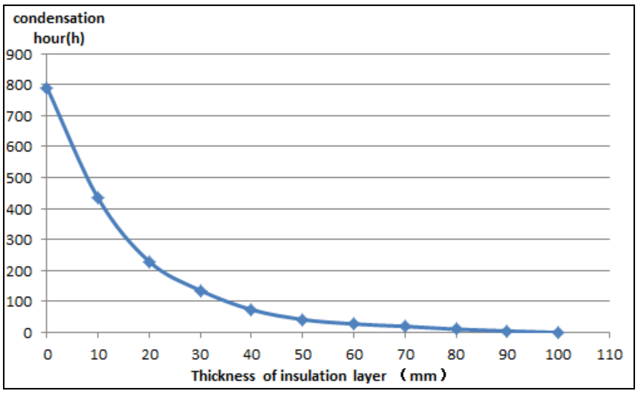



Fig.6. Relationship between indoor temperature and ground temperature from 26th to 28th in June

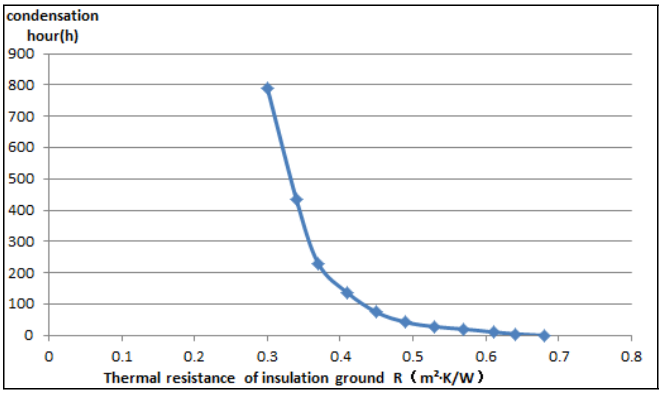
The figures show that: From June 18-20, the ground temperatures were lower than the dew point temperatures, condensation hour number reached 53 hours; From June 26-28, ground temperatures were higher than the dew point temperatures, condensation hour number was only 4 hours. Meanwhile, ground temperatures were lower than indoor air temperatures, the ground could release cooling radiation to the indoor and lower the indoor temperature, preventing the indoor temperature too high. So in the hot season, the ground temperature is lower than the indoor temperature, and can reduce the indoor temperature, while in the wet season, the ground temperature is too low to increase condensation hour number.

### *3. 3 The improvement to the condensation condition by using thermal insulation ground*

Based on condensation of rural cement ground, the insulation ground can eliminate condensation of the ground[6]. Its principle is that through the ground added insulation layer, the indoor surface temperature is increased. When the ground temperature is higher than the dew point temperature, condensation will not occur. So, based on the actual situation in rural areas, the economic application - full lightweight concrete was chosen as the thermal insulation layer to simulate the data of temperature and relative humidity from the 10-100mm thickness , setting the interval was 10mm. The total thermal resistance of thermal insulation floors were from 0.30 to 0.68$m^2$ • K/W.



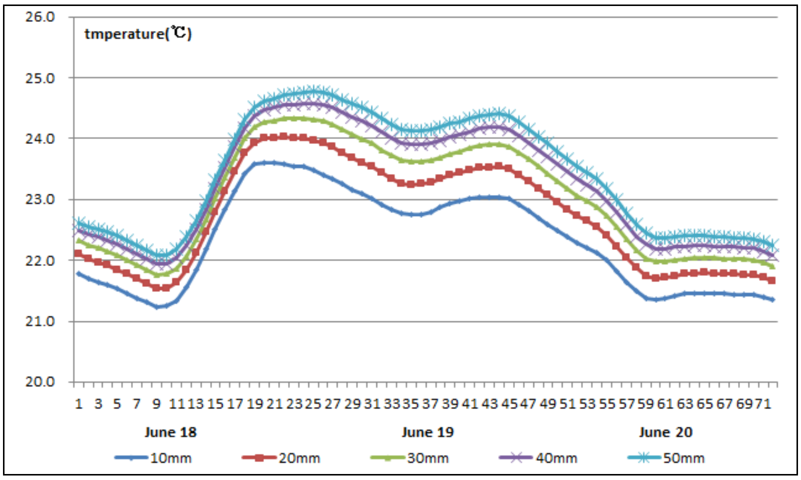

. Fig.7. Relationship between condensation hour number and thickness of insulation layer.




. Fig.8. Relationship between condensation hour number and thermal resistance of insulation ground.

Figure 7 shows condensation hour number in different thickness of insulation ground from March to July. With the increase of the insulation layer thickness, condensation hour number decreased. When the insulation layer increased from the 10mm to 50mm, the condensation number reduced obviously. Continuing to increase the thickness of the insulation layer, the decrease rate tended to be gentle, and condensation number tended to 0 hour. Figure 8 shows the relationship between ground condensation and the ground thermal resistance. With the increasing of ground resistance, the condensation number reduced. When the ground insulation resistance value was close to $0.7m^2$ - K / W, the condensation number tended to 0, the condensation phenomena end nearly. Compared with the cement ground, insulation ground can solve the problem of condensation effectively.

Based on the actual condition of the country, the ground insulation design requirements are lower than urban, it is necessary to study on thermal insulation ground in rural areas which can prevent surface condensation, and can't influence the unique advantages which regulating indoor temperature in summer. Meanwhile, it should be economical and practical, and easy to be accepted. According to Figure 7 and Figure 8 analysis, when the thickness of the insulation layer was during the 0-50mm, the condensation numbers reduced significantly. Further increasing the thickness of the insulation layer, the decline of condensation number was not obvious and economical. When the insulation layer thickness was up to 50 mm, the summary of condensation number could be reduced to 50 hours, condensation had no influence on architecture and human beings.




. Fig.9. Comparison of ground temperature and ordinary cement ground temperature in different thickness from 18th-20th in June.

Figure 9 shows the contrast of different thickness thermal insulation layer (0-50mm) surface temperature from the June 18th-20th. With the increasing of the thickness of the insulation layer from 0mm to 50mm, ground temperatures increased from 22.7 degrees to 24.8 degrees. Therefore, the ground temperature rose indeed by using thermal insulation materials in summer, and thermal insulation materials had an impact on the regulation to indoor temperature. Combined with the actual situation in rural areas, the conclusion is that when the insulation layer thickness is 50mm, the thermal resistance value is $0.49m^2 \cdot K / W$, it can eliminate the condensation on the ground, and prevent the summer indoor air temperature too high.

4. Conclusion

According to the actual situation of rural residential area of Chongqing, this paper chose the DesignBuilder software to simulate different ground conditions, including cement ground and thermal insulation ground. From analysis, conclusions were drawn as following:

(1)For Chongqing rural residence, the temperature of the first floor is generally lower 1-2 degrees than that of the second floor. The ground can regulate the indoor air temperature in summer to prevent indoor air temperature too high.

(2)Insulation ground can eliminate the ground condensation phenomenon effectively. Based on structure form in urban areas and combined with the actual situation, when the insulation layer thickness is 50mm, and the thermal resistance value is $0.49m^2$ - K / W, it can achieve good effect of moisture-proof, and play full advantages which regulate the indoor air temperature of rural residence.

**Acknowledgements**

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