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Thermal Optimization Strategy of External Wall in Low-rise Light Steel Keel Structure Based on the theory of thermal bridge

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Abstract. Light steel keel structure is the most mature structure system in low-rise light steel structure residence. Exterior wall skeleton belongs to dense ribbed structure, so its thermal problems of exterior wall are more prominent. From light steel keel structure composition and exterior wall structure, based on the theory of thermal bridge, thermal performance of external wall is analyzed and thermal optimization measures of external wall in low-rise light steel keel structure are put forward. Specific measures are as follows: Firstly, finding the optimum balance point between the structure steel consumption and thermal performance; Secondly, punching in the steel skeleton webs to improve steel column; Thirdly, arranging the non-metal heat blocking between metal components; Finally, choosing external insulation system of outer wall. These measures are not only conducive to eliminate thermal adverse effects, but also can provide valuable theoretical basis for energy consumption analysis of low-rise light steel keel structure residence.

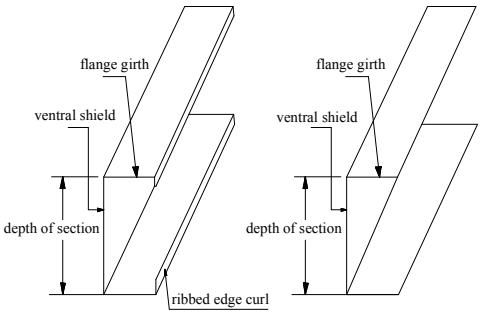
Introduction

As a green energy-saving residential form, light steel structure residential development in China has entered new stage. At present there are mainly two kinds of structure systems in domestic and foreign low-rise light steel structure residence. One is light steel frame structure that is composed of small cross-section profile, such as H-beam steel, C type steel and square steel tube. The other is light steel keel structure that is composed of cold-formed thin-walled steel ribbed structure. Cold-formed thin-walled steel is the most mature structure. Its wall thickness is smaller, so it is also called light steel keel structure [1]. Light steel keel structure belongs to dense ribbed structure, thus its thermal problem is relatively prominent. From light steel keel structure composition and exterior wall structure, based on the theory of thermal bridge, its thermal performance of external wall is analyzed and thermal optimization measures of external wall in low-rise light steel keel structure are put forward. Therefore, some valuable theoretical basis is provided for energy consumption analysis of low-rise light steel keel structure residence.

Thermal Performance Analysis of Low-rise Light Steel Keel Structure

Light Steel Keel Structure Composition and Exterior Wall Structure. Light steel keel structure is often applied to less than three-layer platoon or independent residence, and its structure system is mainly composed of light steel skeleton and enclosure structure. The light steel framework belongs to cold-formed thin-walled steel, whose basic mumbers are mainly two kinds of section form such as C-type and U-type, as shown in Figure 1 [2]. C-type section is used as bearing component such as beam and column, U-type section is used as non-load bearing members such as bottom beam, top

or side beam. The steel thickness of light steel structure is between 0.45mm and 2.50mm. Load-bearing component should generally not be less than 0.85mm and non-load-bearing component can adopt a minimum thickness of 0.45mm.



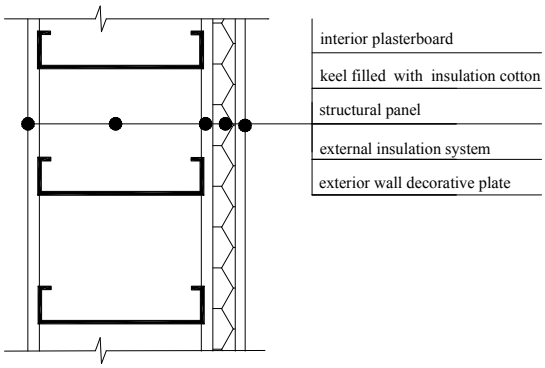


Fig.1 C-type and U- type sectional view Fig.2 Light composite wall

Sandwich light composite structure is often used in light steel keel structure wall, which is composed of light steel keel, structural panel and inner side wall panel. On one hand, the cavity between board and the keel is filled with the glass wool or rock wool to meet the thermal insulation performance of the wall, on the other hand, polyurethane plate is pasted in outside wall to form external thermal insulation system, in order to further enhance the insulation performance of the wall body. Light composite wall is shown in figure 2.

Light steel keel structure mainly consists of wall studs, upper and lower guide beam, brace, rod, wall panel. Column spacing is between 400mm and 600mm, thereby such mode forms dense ribbed structure. The structural panel is a kind of wood panel which is used to enhance the steel structure stability of light steel keel structure. This skin is coated in steel structure outside in order to form a kind of board-rib composite structure[3]. At present, OuSong panels, a kind of waterproof anti-corrosion processed, also called the oriented strand board (OSB board) is widely used to the external wall structural material. It is a kind of new high strength and bearing wood panel, as shown in figure 3. The external wall decorative plate and inner wall plaster board of light steel keel structure are respectively used as outer and medial wall panels.

Fig.3 Oriented strand board and its application

External Wall Heat Bridge Analysis of Light Steel Keel Structure. In building thermal engineering, thermal bridge refers to the building envelope of insulation performance is significantly lower than the other component parts, such as the external envelope structure reinforced concrete or metal beam and column. On light steel keel structure, because external wall skeleton system belongs to dense columns structure, there are a large number of embedded steel columns, steel beams and other metal components in external wall skeleton system. Thus they will become the weak link of heat transfer. If these thermal bridges cannot be fully considered, then the residential energy consumption calculation results would be too small. The design of residential

building will not reach the expected effect of energy saving, so for winter heating and summer cooling energy consumption will increase obviously. Due to the existence of steel keel, the local heat loss of light steel keel composite wall will increased significantly, resulting in the wall interior surface condensation and wall internal condensation.Such there is the formation significant heat bridge effec of steel keel.

With the increasing of residential energy conservation standards requirements, required wall insulation effect will be better, thus the thermal bridge effect is notable. Therefore, wall heat bridge effect of light steel keel framing should be paid special attention.

Thermal Optimization Strategy of External Wall in Low-rise Light Steel Keel Structure

Finding the Best Balance Point between Steel Structure Consumption and Thermal Performance. Concerned data shows: on light steel keel structure, thermal performance of external wall column whose space is 600mm is increased by 10% than that of external wall column whose space is 400mm. Thermal performance of external wall column with No. 16 steel is reduced by 10% than the No. 20 steel [4]. When low-rise light steel keel structure is designed, without affecting the structure under the premise of safety, the column space as large as possible or to minimize the thickness of steel should be made to the best balance point between steel structure consumption and thermal property. Such measures less heat transfer will occur at steel column of the wall in order to reduce external wall thermal bridge.

Punching in the Light Steel Skeleton Web to Improve Steel Column. In order to solve heat bridge effect, another effective method is the use of improved steel column, thus the preformed hole of steel skeleton webs can reduce heat transfer.Punching requirements of steel skeleton web plate as shown in figure 4.

If perforated cold-formed thin-walled steel on the heat conduction is blocked, the heat transfer of the heat conduction path along the keel webs can be significantly increased. Therefore, the local thermal bridge effect in light steel composite wall can be significantly reduced. Related experiments show [5]: with not perforated cold-formed thin-walled steel compared, perforated cold-formed thin-walled steel member, the heat insulating performance can be increased by 90%, the structure bearing capacity can be only slightly low 10%. Data shows: Perforated cold-formed thin-walled steel members could been used as wall keel. At the same time gypsum board are taped on both sides and 175mm of mineral wool is filled with the middle. After the test, such heat transfer coefficient of outer wall can reach to 0.26W/ (m^2•K). Therefore, perforated cold-formed thin-walled steel members as wall keel of low-rise light steel keel structure is an effectual measure in orde to reduce the adverse effects of outer wall heat bridge effect.

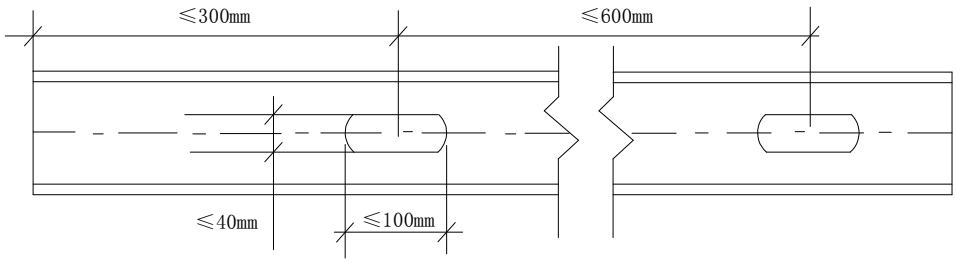


Fig.4 Punching in steel skeleton web

Arranging Non-metal Heat Block between the Metal Components. A non-metal heat blocking designed in the steel structure wall to reduce the heat bridge effect is a kind of effective measure. Too thin heat blocking may be due to contact with the metal too good to increase the heat transfer,

thus additional heat blocking ability is offset by metal cushion block. In order to make the heat block effect obvious, non-metal heat blocking material thickness shall be not less than 10～12mm, and its conductivity should not also be higher than the 1/10 of metallic materials[2]. OSB board could be used as non-metal heat blocking material of external wall column. Therefore, as far as external wall of light steel keel structure, non-metal heat blocking material could be arranged outside external wall keel column to be conducive to eliminate the adverse effect of heat bridge.

Using Wall with External Insulation System. Strengthening the insulation is a kind of efficient way of handling bridge effect. When external insulation for outer wall is used, on the whole outer wall is covered by thermal insulation layer, which is conducive to avoid heat bridge effect. Therefore in order to avoid the bridge phenomenon of external wall skeleton, exterior insulation approach should be adopted in light steel keel structure residential external wall, the proper thickness of rigid insulation layer is placed in the lateral wall skeleton. This measure not only can further improve the thermal insulation performance of light composite exterior wall in light steel keel structure, but also can form the effective barrier between steel and outer interface and can reduce the adverse effects of thermal bridge effect.

Conclusions

As a green energy-saving residential form, light steel keel structure is the most mature structure system in low-rise light steel structure residence. From light steel keel structure composition and exterior wall structure, its thermal performance is greatly influenced by thermal bridge. Based on the theory of thermal bridge, optimization measures for exterior wall of light steel keel residence are put forward in order to eliminate the adverse effects of thermal bridge. Firstly, the best balance point between steel structure consumption and thermal property is found. Secondly, on the steel skeleton web is punched to improve steel column. Thirdly, the heat blocking between the metal components is arranged. Finally, wall with external insulation system is applied.

References

[1] German Energy Agency. The Ministry of housing and Urban-Rural Construction Technology Development Promotion Center. Ministry of housing and Urban-Rural Construction Building Energy Conservation Center Editor. Building energy saving concise textbook—German experience panoramic overview[M]. China Building Industry Press, Beijing, 2009.

[2] C. Ding, Residential design, manufacture and assembly of low-layer light steel frame. China Mechanical Industry Press, Beijing, 2002.

[3] Q. Zhang. Residential design and construction technology of steel structure. China Building Industry Press, Beijing, 2003.

[4] (US)John H Heike, Z. Chen. Residential design and construction of steel structure. China Mechanical Industry Press, Beijing, 2007.

[5] (Finland)Esko Miettinen, B. Ling. Residence of steel structure. China Tianjin University press, Tianjin, 2004.