

Project Outline & Cost Estimation
of

**An Integrated Study on the
Application of Vacuum Insulation
Panels in Ultra-Low-Energy-
Consumption Concrete Prefabricated
Buildings**

QINGDAO KERUI GROUP



Application to: VIPA International

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1 Background and Objectives

1.1 Background

Nowadays in china, in order to control the emission of the greenhouse gases with an aim of 40% - 50% reduction of CO₂, as well as to control the air pollution, the government has addressed the development of the environmental friendly ultra-low-energy-consumption buildings to the national strategy. Moreover, the mode of building-construction is going through tremendous change seeking for transformation and upgrade. Thus, the ultra-low-energy-consumption prefabricated building is under rapid development.

The quality of the prefabricated buildings is highly dependent on the wall materials, insulation materials, doors and windows, pipe fittings, exterior finishes and many other components. Only by fully industrialization of the production of all these components, the industrialization of the prefabricated buildings, or even of the whole construction industry, can be finally achieved. Compared to the requirements for the traditional building components, the ultra-low-energy-consumption prefabricated buildings have higher requirements on the air tightness of doors and windows and the insulation performance. Therefore, in order to achieve the fully industrialization of the components for prefabricated buildings and to ensure the high thermal insulation performance of the exterior walls, the doors and windows, it is necessary to carry out a study on the VIP-integrated-precasted-walls for prefabricated buildings with decorative surface layer.

In the past, the 'sandwich-structure' insulation methods are mainly adopted by the construction of prefabricated buildings, with expanded polystyrene (EPS), extruded polystyrene foam (XPS) etc. as insulation layers. By applying the VIP-integrated-precasted-walls (prefabricated external insulation), several problems will be solved, including reducing the thickness of the enclosure wall, avoiding the cold-bridge generated by the connection of inner and outer walls and also lowering the fire risks.

1.2 State of Art

In the report of IEA/ECBCS Annex 39, case studies of VIPs applied in prefabricated concrete components has been recorded [1]. The prefabricated components were produced from a composite insulation layer made of polyurethane foam board and VIP with a thickness of 27 cm and an average heat transfer coefficient of $0.15 \text{ W}/(\text{m}^2 \cdot \text{K})$. Voellinger etc. studied the applications of VIP in prefabricated concrete sandwich structures [2]. A composite insulation structure made from EPS-graphite (4 cm), VIP (6 cm) and EPS-graphite (4 cm) was produced. Sprengard etc. studied the effect of thermal bridge of the anchor parts in prefabricated VIP-concrete components [3]. It has been shown from the results, an anchor density of 4 per m^2 leads to an increase of 2 % of the U-value of this structure.

The previous studies on applying VIP in prefabricated buildings were mainly focusing on composite insulation layers of VIP and other insulation materials. Case studies for applying VIP independently in prefabricated concrete components are still missing. Moreover, the existing studies are limited in applications for low rise buildings, on the other hand, there are not so far studies on applications for high rise buildings. Applying VIP alone without compositing with other insulation materials is of great importance to explore the possibility of high rise prefabricated buildings.

The safety of the building envelope and the fire protection level of high rise buildings have higher requirements. On 14 June 2017, the Grenfell Tower fire caused heavy casualties, which was indeed due to the flammable external cladding. Therefore, for

the development of high rise prefabricated buildings, the thickness of the prefabricated components shall be reduced and the fire risks caused by flammable insulation materials, such as polyurethane, shall be minimized.

In conclusion, composite VIP insulation materials will not be considered in the presenting study. The study will be carried on to apply VIPs independently in prefabricated buildings with surface modification by inorganic materials, followed by property characterizations.

[1] A Binz, A Moosmann, G Steinke, et al. Vacuum insulation in the building sector. Systems and applications (Subtask B), Final Report for the IEA/ECBCS Annex 39 HiPTI-project High performance Thermal Insulation, 2005.

[2] T. Voellinger, A. Bassi, M. Heitel, Facilitating the incorporation of VIP into precast concrete sandwich panels, *Energy and Buildings*, 85 (2014) 666–671.

[3] C. Sprengard, A. H. Holm, Numerical examination of thermal bridging effects at the edges of vacuum-insulation-panels (VIP) in various constructions, *Energy and Buildings*, 85 (2014) 638–643.

1.3 Tasks and Methods

- Developing a method to protect the surface of the VIPs at the pouring step of the concrete assemblies. A low-cost protection mortar shall be coated on the surfaces of VIPs through a mortar spray machine, forming a dense protective layer, which shall lower the impact from the construction aggregates on VIPs as well as the damage caused by the concrete vibrator spear.
- A detailed study on the formulation of the low-cost mortar. Increase the fineness, shorten the coagulation time, increase the bonding strength of the mortar by adding and adjusting the amount of the functional additives. The testing of its performance shall be carried out.

- Studies of the influence of the thickness, size, number of layer, 'patchwork' and anchor parts on the heat transfer coefficient of the prefabricated components. Based on individual cases, measure the overall performance of the VIP insulation layer applied in concrete prefabricated buildings with the help of thermal imaging technology.
- Development of an appropriate testing method to evaluate the thermal performance of the final product. Building the VIP-integrated-precasted-wall by anti-molding construction technology. The heat transfer coefficient shall be measured on site with temperature control box – heat flow meter method. Comparing with the measured values, correction factors shall be determined for compensating the heat loss caused by the thermal bridge.

1.4 Objectives

- To explore the different methods for application of VIPs in ultra-low-energy-consumption prefabricated buildings. To develop methods to produce VIP-integrated-precasted-walls with decorative surface layer.
- To achieve an average heat transfer coefficient of $0.15 \text{ W}/(\text{m}^2 \cdot \text{K})$ of the integrated-precasted-walls with decorative surface layer, to fulfill the requirements for the enclosure walls of the ultra-low-energy-consumption buildings.

2 Available Resources

2.1 Software and Hardware Facilities

Qingdao Kerui Group is an enterprise specializing in research, manufacturing, sales and construction of insulation materials (construction, industrial and civil use) and paint materials, which owns four production bases in Qingdao, Wuhu, Urumqi and Tianjing.

The R&D center of Qindao Kerui covers an area of 1,200 square meters, which includes one of the best equipped laboratories for insulation material studies in China with a variety of equipment for research and testing, including the microcomputer controlled electronic universal testing machine, pressure testing machine, hydraulic universal testing machine, heat flow meter for thermal conductivity measurement, rapid thermal conductivity tester, guarded hot plate apparatus, differential scanning calorimetry and heat capacity apparatus for construction materials, etc.

Kerui has filed for 235 national patents, 9 international patents and has been authorized for 185 patents so far, including 105 invention patents, 66 utility models and 14 appearance patents. Kerui was in the committee of composing of two national standards for construction industry, which are ‘建筑用真空绝热板’ (Vacuum Insulation Panels for Construction) and ‘建筑用真空绝热板应用技术规程’ (Technical Specification for Application of Vacuum Insulation Panels for Construction). Kerui was also the editor of 15 local standards and atlas. Currently, Kerui is undertaking 3 national key research and development plans from the Ministry of Science and Technology of China.

2.2 Financial Support

A self-financing funding of € 30,000 has been planned. A special account for managing research funding shall be set up for providing adequate financial support to ensure the accomplishment of the proposing study.

3 Cost Estimation and Time Schedule

In order to be able to carry out the investigation properly, an amount of

€ 10,000-(net)

will be necessary for the above proposing study. We are flexible to adjust the investigation program to the needs of the VIPA members. The studies can be carried out starting from May 2017. Time required to carry out the study is 8 months.

3.1 Terms of Payment

50 % at the start of the project.

50 % after completion of the evaluation of the final report .

3.2 Further conditions

3.2.1 Review

After submitting the final report VIPA has 2 weeks for review. Requested changes or comments will be applied to the report by Kerui within reasonable time, not exceeding one month. After completion of this evaluation, the second half of the payment is due.

3.2.2 Delays

If the deadline of (to be defined) cannot be met by Kerui, a discount of 500 € for every month of delay will be granted. This term is only valid for delays caused by Kerui. If force majeure delays are occurring, Kerui can request for extension of the project without granting aforementioned discount.

3.2.3 Termination

If severe breaches of the terms and conditions of this contract occur the contract can be terminated. Possible payments can be reimbursed.

3.2.3 Arbitration Clause

Chinese law will be applicable to this contract.

Qingdao Kerui New Environmental Materials Group Co.,Ltd

August 7th, 2017

Signature:



李壮贤 (Zhuangxian Li)