

Hainan International Expo non-linear roofing; application of waterproofing, insulation and GRC system

D. SONG

Guangxi Qinglong Chemical Building Materials Co. China

Abstract

This paper systematically introduce design and construction of 120, of profiled steel roofing of Hainan International Expo., including waterproofing, insulating and GRC decoration, pointing out that roofs sloped more than 60°and skylights are the most difficulties. It details EVB thermal insulation mortar and GRC finishing material.

Keywords: Profiled Steel Roofing, Waterproofing, EVB Thermal Insulation Mortar, GRC Finishing Material, Mortar Spraying

PROJECT OVERVIEW

Hainan Int. Expo was the priority construction of Hainan government and Haikou government. It includes exhibition centre and conference centre it is now a Hainan international corporate and high-end business activities service platform, as well as the center of the public and tourists daily leisure, tourism, sports and other activities. It is now becoming a unique "city card" of Hainan Province.



Figure 1. Hainan International Expo

ROOFING SYSTEM DESIGN

This project is with irregularly steel structure profiled roofing, its steel structure and housing are all bidirectional bending and twisty, roofing area is about 120,, it is now currently largest roof of this type in the world. The highest point of this wavy roof is more than 30 metres, lowest is about 10 metres. But it is hard for application, time urgently and high quality requirement. So it not only required good material and excellent skills, but also rapid construction.

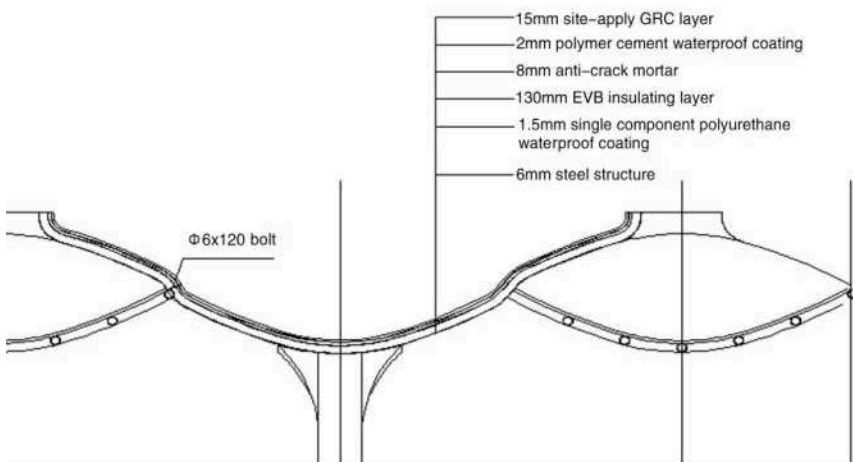


Figure 2. Roofing structure

MATERIALS AND SPRAY DEVICE INTRODUCTION

Material

This project is near seashore, due to the influence of local marine climate, it should fully take into consideration about the waterproofing, insulating and GRC material to make sure the roofing safety, durability, economy and beauty. It used single component polyurethane coating and polymer cement-base coating as 2-layers waterproofing, used “QINGLONG” EVB insulating mortar as insulating material. For GRC layer, it used importing material for site application (GRC for skylights was pre-made for installation.)

EVB insulating mortar

“QINGLONG” EVB mortar is made by EVB bead, inorganic insulation binder, polymer modifier, cement and ant-crack fiber etc., mixed with water when application. This mortar’s advantage is as follows:

- Stable.
- Good overall (insulating layer fully adhesive with substrate, forming a continuous cavity-free system. Site application can be any design, it is good for profile substrate).
- Durable (fire-proof, waterproof, weather resistance, freeze-thaw resistance).
- Good combination property(light density, non-hollowing, non-crack, good adhesive, environmentally friendly).
- Easy application(With mechanical spraying process and construction of manual finishing process).

Item	Index		
	I	II	This project
Dry density	240-300	301-400	600
Slurry density	≤680	≤880	
Heat conductivity	≤0.07	≤0.085	≤0.12
Pressing strength	≥0.2	≥0.4	≥1.5
Tensile strength	≥120	≥120	
Adhesive strength	≥100	≥100	

Table 1. EVB insulating mortar technical data

GRC decorative material

The material for this project is introduced from US, special for Hainan's climate characteristics, like high temperature, high humidity, Typhoon-prone etc. Its main components are: high-strength cement, fiberglass, sand and admixtures.

The GRC material has the following advantages,

- 28days later, Bending strength >5MPa, compressive strength >35MPa
- With alkali-resistant fiberglass as a reinforcing material , its strength up to 8-11MPa
- Superior impact resistance, up to 10-25MPa
- Good durability, architecture life > 50 years, half-life > 80years.
- Using fiberglass can effectively prevent products from cracking
- GRC products are inorganic material, flame-retardant, no smell, no harm to humans and the environment.

Item	Index
Pressing strength	≥40
Ultimate bending strength	≥10

Table 2. GRC material technical data

Mortar spray device

This device consisted of batching system, mixing system, conveyor system and spray system. After setting, it works continuously, high efficiency, widely used for insulating mortar, mortar, anti-crack mortar and GRC mortar.

This device has following advantages:

- a. Batching systems is precious and multiple formulas can be stored, can make proportion control to multiple units material.
- b. Forced mixing system is with high power, large drum capacity, high efficiency and uniform.
- c. Conveyor system is with high pump lift, long delivery distance. Good for high viscosity, fluid impurities and light material.
- d. Unique non-sealing structure, without any leakage, with a self-cleaning ability.
- e. Simple installation and maintenance, low maintenance costs, simple operation, the flow can be adjusted.
- f. Unique airbrush design, spray flow can be adjusted, suitable for different materials
- g. Easy to clean maintenance and long shelf life.

ROOFING SYSTEM CONSTRUCTION

Construction process

This roofing system construction process: 6mm steel structural panel ($\phi 6^*120$ steel bolt) → 1.5mm single component polyurethane coating → 80mm thermal insulation mortar → $\phi 16$ hot-dipped galvanized double steel wire mesh → 50mm thermal insulation mortar → Cut separation slit → lay #20 exhaust pipe and liquid sand → 4mm anti-crack mortar layer → anti-alkali mesh → 4mm anti-crack mortar layer → apply polymer modified cementitious waterproofing coating → GRC slit → 7mm GRC mortar layer → anti-alkali mesh → 8mm GRC mortar layer → sealant for separation slit → protection agent → Project acceptance.

Construction arrangement

Taking the maximum delivery distance and conveyor pipe layout into consideration, we divided this roofing into several working area. The device completed every task after installation, ensure to complete maximum task with least moves. Reduce installation and improve construction speed. Arrange teams to finish one or two area every day, following process catch up when previous process finished, each process is in an orderly way to guarantee period.

Construction Technology

Substrate requirement

Weld $\phi 6^*120$ mm bolt on steel housing, tubular joint and steel purlin, bury electricity pipelines and lightning device on the roof, clean substrate.

Polyurethane waterproof coating application

- a. Mix polyurethane waterproof coating: open the barrel and mixing.
- b. Reinforced waterproofing for joints: first waterproofing layer for welding, slocker, skylight, gutter etc.
- c. Apply polyurethane waterproof coating: Fully mixing the PU coating then pour into the substrate, evenly scraping, , first layer should be less than 0.7mm, when it is surface-dry, apply second layer, which is vertical with the first layer

Insulation Layer Construction

- a. Supplying pipes settlement: According to the construction area to arrange the supplying pipes, adapt to high to low and far to near construction method to apply and remove the pipes. With steel button to fix the tube to steel frame, with wood to raise the flat tube and

- avoid damage to the waterproofing layer when supply material with pump.
- b. Thermal insulation material preparation: Make up the material according to the best ratio, then delivery to mixer, and mix in 3-5 mins to get paste, then to the storing container.
- c. First insulation layer Construction: To spray the paste into the construction area to get 80mm insulation layer and strike it evenly by hand.
- d. Apply steel mesh: Fix the #16 hot dip galvanized two-way steel wire mesh to bolt after the insulation layer is strong enough.
- e. Second insulation layer construction: Spray 50mm insulation layer after applying steel mesh and bolts. The thickness of insulation layer could be
- f. Adjusted according to the height of welded bolt. Flatten the layer, after it dry, Quality should reach to the design and quality requirement.



Figure 3. Insulation layer construction

- g. Separation joint construction: Put 25mm x 30mm square bar into the separation joint after half an hour of insulation layer, the project spacing is 3600 x 3600mm. when the insulation layer is strong enough, apply 20mm PVC pipe with filter screen to the separation slit, lock it and fill in the gap with asphalt sand. Set the steam vent on side of skylight, gutter, roof platform, 200mm higher than decoration layer, and use 180°bending pipe.

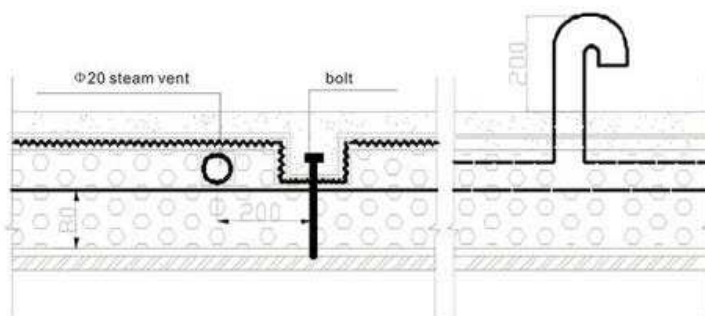


Figure 4. Steam vent

Anti- crack layer construction

Mix the anti-crack mortar into paste, then directly spray into the insulation layer after the insulation layer is completely dry. First with 4mm thickness, then apply with fiberglass mesh, then another 4mm layer and polish by hand at last.



Figure 5. Applying fiberglass mesh



Figure 6. Applying fiberglass mesh

Polymer modified cementitious waterproofing layer construction:

Brush polymer modified cementitious waterproofing coating on the anti-crack layer , After the above layer is dry, brush the second layer in vertical direction, about 0.7mm thickness for each layer, total 2.0mm thickness.

GRC Decoration Construction

- a. Make GRC separation slit: directly fix 10 x 15mm extrusion sheet with polymer cement on waterproofing layer, layout space 1800 x 1800mm.
- b. GRC Decoration Construction: Prepare GRC material on best ration after testing, mixing for 4-5min ,make sure the change to uniform paste, then convey to roof, used high strength empty pressure airbrush continuous spray to roof which waterproof layer was fully dry. Continuously spray to 7mm thickness, press into a 160g alkali-resistant glass fiber mesh, continue to spray, meanwhile, densify the GRC mortar, when thickness up to 15mm , instantly plaster and polish.
- c. Separation slit sealing: after GRC layer, clean the slits and seal with weather-resistant glue.
- d. Transparent protection layer application: clean the substrate then apply a transparent protection agent.

Processing site construction

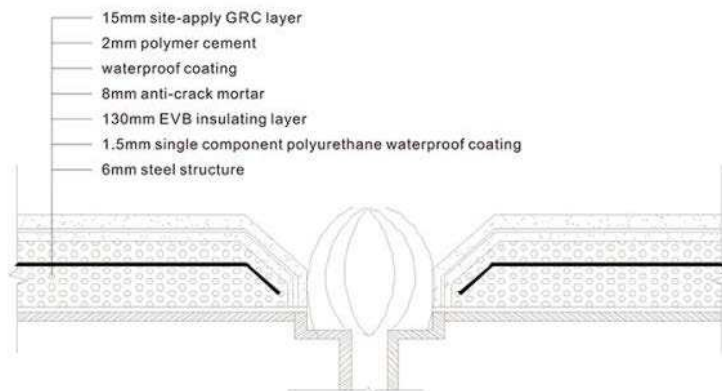


Figure 7. Water inlet

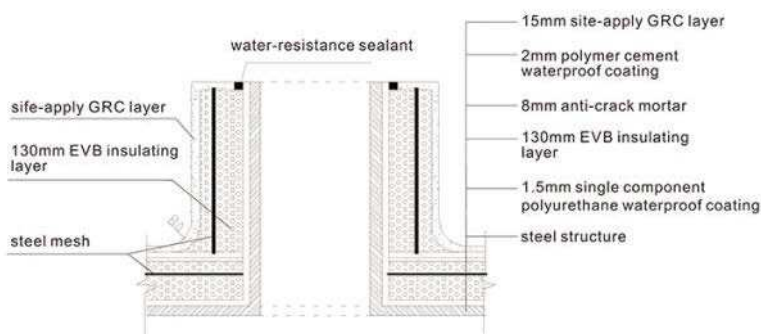


Figure 8. Skylight

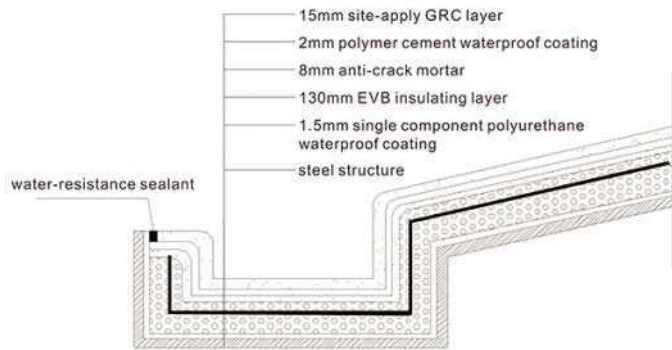


Figure 7. Gutter

Difficulties construction

- The roofing with over 60° slope: after Waterproof layer completed, we install approximately 1M x 1M protective scaffolds, use rubber mat to protect the waterproof layer. Made 800 x 800 mm templates, when pumping the thermal insulation mortar, extend one smaller pump to add concrete accelerator to shorten initial setting time of mortar, preventing the mortar movement. After GRC layer finished, use split-back technique to remove the scaffolds, repair if necessary.
- Skylight: After several days conservation of insulation layer and anti-crack layer, apply steel mesh on the side wall of skylights, wire with vertical steel mesh, then fix the Prefabricated GRC panels by hang-fixing method. Fill in the gaps with insulation mortar.



Figure 10. Construction difficulties



Figure 11. Construction difficulties

CONCLUSION

There was not similar engineering construction experience for such large non-linear steel structural roofing for Hainan Int. Expo. This project has waterproof layer, insulation layer, anti-crack layer and GRC layer on the profiled steel roofing. Due to right material and reasonable technology chose, it only took 4 months to finish this roofing without crack and hallowing Design and construction of this engineering is now a success for reference.