Study of the architecture composite materials with enameling steel panels and honeycomb-aluminum

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Abstract: The properties of different back-up materials on the enamels have been analyzed in this paper. The new architecture composite materials with enamel and honeycomb-aluminum have been developed by special adhering technology for the enameling steel panels and honeycomb-aluminum. The properties of new architecture composite materials have been tested and compared with that of the traditional architecture enamel materials. The results show that the new architecture composite materials with enameling steel panels and honeycomb-aluminum have many good properties, such as: excellent chemical stability, light weightiness, high stiffness and flatness, excellent mechanical shock, flexible size and shape etc. These kinds of materials have greater developing potential as architecture decorating materials.

Keywords: enameling steel panels, honeycomb-aluminum, architecture, decorating material

1. Introduction

Architecture enameling steel panels is one of the fastest growing enameling products. It has been widely used as decoration materials in subway stations, tunnels, underground pavements, art wall paints, airports, railway stations, etc. Since special application requirements for architecture decoration materials, enameling steel panels which are used as architecture decoration, should meet many new demands, such as, excellent chemical stability, thirty-years zero-repairing, easy clean, low cost maintain, safety and environment protecting, fire-proof, without poison, without radiation, multi-color and colorful, art decoration effect, flexible size and shape, especially, large-size enameling panel with high stiffness and flatness etc.

Back-up materials are used as back of enameling steel panels for reducing noise and vibration, thermal-insulation, increasing mechanical strength etc. Normally, Back-up materials for enameling steel panels are aluminum honeycomb, calcium silicate panels, gypsum panels and fire-proof coatings etc. Combination of back-up materials and enameling steel panels will affect mechanical strength, flatness and architecture decorating effect.

2. **Architecture composite materials manufacturing technology**

Characteristics of back-materials are shown as following:

A. **Aluminum honeycomb**

Physical properties of aluminum honeycomb are shown on Table1. The air is separated and sealed inside aluminum honeycomb, and thermal energy loss is reduced dramatically. Aluminum honeycomb back-up materials have excellent heat insulation performance, besides, environment protecting, energy-saving, light-weightiness and high mechanical strength.

Table 1 Physical properties of aluminum honeycomb

material	thickness /mm	high /mm	Node strength N/cm
3003H19	0.076	10-25	39.8
Surface compress strength/MPa	Surface compress elasticity modulus/MPa	Surface shear strength/MPa	Surface shear elasticity modulus /MPa
1.21	91	0.673	8.15

B.Calcium silicate panels

Calcium silicate panels consist of mullite, cement, quartz and inorganic fiber. The composite materials with enameling steel panels and calcium silicate panels have the advantage properties of high mechanical strength, good thermal-insulation and sound-insulation, and the disadvantage properties of high weightiness, easy deformation after absorbing moisture.

C. Gypsum panels

Gypsum panels have the advantage properties of light-weightiness, fire-proof, sound-insulation, warm-keeping, thermal-insulation, easy-processing and installation, and the disadvantage properties of low Flexural strength, easy-broken.

D.Fire-proof coatings

The fire-proof coatings are mainly used when enameling steel panels are arc and irregular form. The advantage properties are, besides fire-proof coatings, anti-rusting, abrasion-resistance, thermal-resistance, as well as tough, colorful, adherence, easy to dry and brightness.

Composite materials with enameling steel panels and honeycomb-aluminum are made by compressing enameling steel panels, honeycomb-aluminum back-up and galvanized steel sheet together. The fabrication technology of composite materials with enameling steel panels and honeycomb-aluminum is described by enameling technology and compressing technology.

2.1 Enameling technology

Enameling technology consists mainly of: blanking → cutting angle → bending → welding → polishing →surface treating → static electric powder application → firing →

inspecting → filming for protecting.

The steel sheet with carbon content wt% below ≤0.008%for enameling is selected, and processed into various shapes and sizes.

Enameling steel sheets are made by static electric powder application and two coats/one fire technology. The firing temperature is 820-850℃, and enamel layer thickness is 120-200μm. The application and firing technology could be changed a little according to color demands and environment temperature.

2.2 Compressing and combination

Since the difference among enameling steel sheet, honeycomb-aluminum back-up and galvanized steel sheet, it is very importance for selecting the adherence agents and compressing-combination technology. Each layer thickness also needs to be calculated carefully according to designing requirements. Normally, honeycomb-aluminum back-up layer thickness is 10-15mm, and galvanized steel sheet layer thickness is 0.5-0.7mm.

Sizes of honeycomb-aluminum back-up and galvanized steel sheet are selected according to the size of architecture composite materials. Normally, size of honeycomb-aluminum back-up is 10-20mm larger than that of composite materials, and Sizes of galvanized steel sheet is 10-12mm smaller that of composite materials. Galvanized steel sheet surface must be treated so as to remove oil dirty.

Surface treating technology for combining is as following: First, back-up materials and compressing table should be treated for removing any foreign matter, such as, dirty, dust, glue etc. Second, enameling steel sheet and galvanized steel sheet surface should be treated for removing stain, dirty water, dusty, welding slag, powder etc.

Epoxy resin must be mixed strictly according to mixing proportion of A and B. After mixing homogenously by stirrer, epoxy resin should be overlaid on the surface of adhered matters uniformly and quickly. 0.9~1.1Kg epoxy resin is used for one square meter enameling steel sheet. After overlaying, adhered maters should be combined within two minutes in order to avoid combining strength decreasing. If the working temperature is higher, the mount of epoxy resin is used as little as possible. Otherwise, epoxy resin reaction will be accelerated, and working time will be shortened. After epoxy resin mixing, it should used up within 20-30minutes.

Fix-formed honeycomb-aluminum is putted smoothly on the enameling steel sheet, and compressed gently. After that, galvanized steel sheet with overlaying epoxy resin is putted on the fix-formed honeycomb-aluminum, and compressed gently in order to keep enameling steel sheet, honeycomb-aluminum and galvanized to closing together.

There have three kinds of compressing machines: cold compress table, cold compress machine and hot compress machine. Cold compress machine is used for honeycomb-aluminum as back-up. Full-load of compress panel is adjusted from 4 ton to 7 ton automatically. The highest layers is limited 25 layers. Cold compress table is used for special-shaped panels, and each group has 5-6 compress bars. Compress bar must keep highly consistent straight. The position must be putted equally, specially the rim of plate. Hot compress machines is only used for flat panels, and the highest layers is limited 6 layers. The largest size of flat panel is 1300mm×2500mm. The compressing time is about 30-35 minutes for epoxy resin solidification.

3010-type of AB epoxy resin is used. The ratio and solidification time are shown on table 4. Layer-stacks picture of composite materials with enamel and honeycomb-aluminum for cold compress machine are shown on fig.1.

Table 4 Ratio of epoxy matrix (A) and solidification agent (B) and solidification time

materials	ratio	Solidification time
3012	A2:B1	≥ 17℃（over 12hours）
HD 3012		
3012 AW	A2:B1	≤ 17℃（over 12hours）
HD3012 AW		

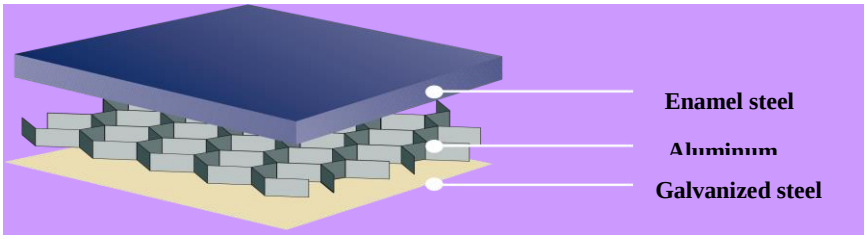

Fig.1 Layer-stacks picture of composite materials

3. Composite materials properties with enameling steel panels and honeycomb-aluminum

composite materials with enameling steel panels and honeycomb-aluminum have many excellent chemical-physical properties, such as, acid resistance, alkali resistance, abrasion resistance, impart resistance, fire-proof, safety and environment protect, anti-static electric, besides, low-weightiness of honeycomb-aluminum, good rigidity of enamel steel sheet, good anti-seismic. The unevenness of composite materials with enameling steel panels and honeycomb-aluminum is less than 1 mm.

3.1. Thermal and mechanical property

Surface tension strengths of composite materials with honeycomb-aluminum and calcium silicate under different temperatures have been tested. The results are shown on table 5.

Table 5 Surface tension strengths under different temperatures

temperature / materials	Room temperature		High-low temperature		freezing	
	tension strength （MPa）	state	tension strength （MPa）	state	tension strength （MPa）	state
MG3012 （honeycomb-aluminum）	1.98	honeycomb-aluminum break	0.82	Separate between honeycomb-aluminum and galvanized steel sheet	1.35	honeycomb-aluminum break
MG3012 （calcium silicate）	0.95	calcium silicate break	0.73	calcium silicate break	0.35	calcium silicate break

Note: Freezing testing: specimen are placed in room-temperature water for 48 hours, transferred into （-20±2）℃ temperature freezer for 4 hours, then, melt by flowing water for 4 hours. This above test should be repeated for 25 times.

High-low temperature testing: Specimens are placed automatic-cycle box, and cooled according to cooling program: （-40±2）℃ for 2 hours, then heated to （80±2）℃ and kept for 2 hours. Heating rate is 1℃/min. This above test should be repeated for 50 times.

It could be found from the above testing that under freezing testing and high-low temperature testing, the surface tension strength of composite materials with honeycomb-aluminum is higher than that of composite materials with calcium silicate

3.2 Drawing, bending, sound insulation

The mechanical properties of composite materials with 1.5mm thickness enameling steel sheet, 15mm thickness honeycomb-aluminum and 0.7mm thickness galvanized steel sheet are tested, and the results are shown on table 5.

Table 5 the mechanical properties of composite materials with 1.5mm enameling steel sheet, 15mm honeycomb-aluminum and 0.7mm galvanized steel sheet

Surface	Surface	Surface shear	Bending	Bending

tension strength	compress strength	strength	rigidity	strength
MPa	MPa	MPa	$N.mm^2$	MPa
1.42	1.13	0.51	2.93×10^9	97.4

It could be found from the above testing that under freezing testing and high-low temperature testing, the surface tension strength and bending strength of composite materials with honeycomb-aluminum is lower than that of composite materials with calcium silicate since composite materials with honeycomb-aluminum has low weightiness.

Sound insulation is one of the most importance properties. Sound insulation of composite materials with honeycomb-aluminum is shown on fig.2.

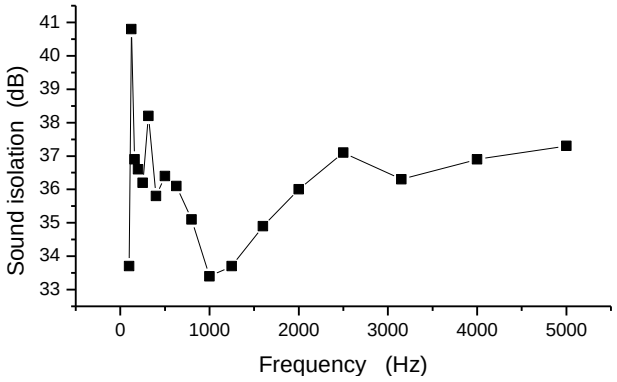

Fig.2 relation between sound isolation and frequency

It could be discovered from the testing results that average sound isolation of composite materials with honeycomb-aluminum is 36db, which is much lower than that of composite materials with calcium silicate, 45-60db. It is also lower than that of china construction sound isolation standard requirement（≤40db）.

4. Application and prospect

Architecture composite materials with enameling steel panels and honeycomb-aluminum are one kind of fast-growing products in recent years, which have been applied widely in subway stations, tunnels, public facilities, bus stations etc. Architecture composite materials with enameling steel panels and honeycomb-aluminum have many advantages, such as, low weightiness, high rigidity, impact resistance, large size, various forms, high flatness, etc, and will become one of the most potential developing decoration materials.

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