

## Development prospects of combination decorative concrete & GRC

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### Abstract

The use of natural rock ballast and dust as aggregates in the facing layer not only embodies a stone texture, but also consumes the industrial waste, consequently protects the ecological environment. The backing layer is made with sprayed GRC with additional glassfibre mesh. Combined with stud frame, this type of construction enables a light-weight decorative concrete element, also the structural reliability is improved.

Building materials serve architecture and architecture is accomplished from building materials using research and development as guide, creative design as keynote, the bespoke “Baogui Stone” cladding panels greatly inspire the imagination of architects and propel the harmonization of architecture and materials, environment and culture. This joint force pushes forward the cladding industry and provides a successful case study for the industrialization of the industry.

**Keywords:** glassfibre reinforced concrete (GRC), decorative concrete, facing layer, backing layer, stud frame, light-weight, reliability, Baogui Stone

## CHARACTERISTICS OF TRADITIONAL GRC ELEMENTS

### High mouldability

The most prominent characteristic of GRC elements is the ease of moulding, thanks to the mould making and GRC prefabrication technics. There are completed project cases of almost any shapes, from architectural moulding in the early days to the cladding panel now days, salient corner unit, concave angle unit, corrugated panel, U-shape panel, single-curved panel, multi-curved panel etc. As an appearance characteristic, the high mouldability also tells how GRC differs from other building materials and why it is being widely used.

### Light weight and high strength

It is well known that GRC has high flexural strength and compressive strength, high impact strength and good toughness. Due to the use of glass fibres as reinforcement, the thickness of elements is reduced and so is the weight, therefore, light weight and high strength is the technical characteristic of GRC.

### Good durability

In 1970s the GRC industry came through a rapid development time, and then slowed down a lot due to the results of 10 years' natural environment exposure test carried out in Britain. Later on, through the improvement of glass fibre and modification of cementations matrix, the durability was improved significantly, leading to the wide used of GRC element. Good durability is the safety characteristic of GRC.

### Ease of installation

The combination of GRC unit and stud frame greatly simplifies the installation process, especially when used as cladding panels. As a structural element, the stud frame provides a

supporting structure, enabling the GRC unit being made lighter, thinner, larger and unique. The stud frame is connected to the main structural through bolts and nuts, which ensures a flexible connection, thus simplifies the installation and reduces the construction time. This is the application characteristic of GRC.

## TYPICAL CHARACTERISTICS OF THE COMBINATION OF DECORATIVE CONCRETE AND GRC

Considering to increase the plot ratio and to save time and energy, the Japanese architect Tadao Ando firstly discovered the charm of fair-faced concrete, which latterly become a popular architectural style. However, using steel rebar as reinforcement, fair-faced concrete is thick and heavy like a warrior wearing armor. Here is question, without the requirement to bear load, must the decorative wall panel be reinforced by steel rebar? Is there a way to decorate the building with lighter materials like silk? Therefore A new type of cladding panel was developed using the vibrating formed decorative concrete as facing layer, hand-sprayed GRC with additional AR glass mesh reinforcement to increase the toughness as backing layer, the back of the backing layer is further stiffened with GRC ribs or stud frame, and this panel is named Decorative Concrete Light-weight Cladding Panel (DCLCP)[Figure 1]. According to the former president of China GRCA, it is not only a building construction material but also an artistic sculpture material, which embodies the aesthetics, texture and power of the architecture, enables architects to exert their imagination and creation. In another word, this material is favored by architects because the latter can employ the material to express the aesthetics, to adopt advanced design to achieve aesthetics, to use architectural shape to embody the aesthetics and to use arts to create aesthetics.



**Figure 1** Decorative Concrete Light-weight Cladding Panel (DCLCP)

The typical characteristics of this combination cladding panel that differs from the traditional GRC elements are as follows,

### Texture

Many traditional GRC products adopt stone-like coating or fluorocarbon coatings to achieve colours. On the one hand, this type of coating is lacking in expression and on the other hand, the coating will eventually peel off and crack, sometimes even shelter dirt. The DCLCP uses natural rock ballast and dust as aggregate in the facing mix, the decorative colour is achieved through the exposure of rock ballast and dust.

Although colours are not as varied as palettes on the computer, the embodiment of the true color of natural rock ballast and dust is attractive enough. Because the colour is from inorganic natural materials, it is stable and will not fade. It is important to choose the size and colour combination of rock ballast and dust, which will ensure the strength of the facing layer and visual verisimilitude. The method of acid etching, grinding, retarding, chiselling is normally used to expose the aggregate [Figure 2].



**Figure 2.** Texture

In Baogui stoneart, we use the combination of chiselling and grinding. When the facing layer is chiselled, the rock ballasts are broken due to high bonding strength of ballasts and cement. The exposed ballast section is absolutely natural, thus endows the DCLCP products a stone texture. Just because of this processing technology of simulating natural stone, decorative concrete products have the texture of stone materials, which is beyond the limit of concrete products. The effect of other materials like wood and metal can be achieved by the use of various moulding materials [Figure 3].



**Figure 3.** Various surface finish

### Environment Protection

Our initiative of using rock ballast and dust as aggregate was simply to simulate the natural stone effect. Later on it happened to meet the state policy of tax exemption due to the use of waste materials, thus we are walking on a path of comprehensive utilization of resources. The following is our environment protection stories: A sculpture named 'Conversation' was given to the former vice president of the United State, Mr Gore, as a state present by the minister of Ministry of Science and Technology of China [Figure 4], low carbon footprint characteristic was emphasised.



**Figure 4.** A state present given to Mr Gore

At the Beijing Olympic Games' one-year countdown opening ceremony, the unveiled sculpture [Figure 5] was made with concrete, named by organizing committee as 'Environmental Friendly Artificial Stone'.



**Figure 5.** Decorative concrete sculpture for Beijing Olympic Games

It was the first sculpture being made for that game to show the importance of environment protection. Later on the circular and relief sculpture at the Triathlon track and the relief in BMX stadium were also completed with this material. Other project cases include the 50 metre-long Olympic picture scroll and Olympic Five Ring decorated ground and wall at the Beijing Olympic Village stand at Shanghai World Expo [Figure 6], the hollowing fret wall at classic Beijing grey colour in the main hall of the recently closed APEC meeting [Figure 7].



**Figure 6.** Beijing Olympic Village stand at Shanghai World Expo



**Figure 7** Hollowing fret wall at Beijing APEC meeting

In particular, this material was also successfully used in the building renovation. Some of the ceramic tiles on the Architecture College Building, Tianjin University, fell off and renovation started just before 2014 [Figure 8].



**Figure 8** Ceramic tiles falling

Taken into consideration of historic inheritress and reduction of construction waste, the original titles were ground and sieved as aggregate to make cladding panels. Although the texture change somehow compared with the original tiles, the panels still bears the imprint of the latter [Figure 9]. This building was nominated as a modern architectural heritage years ago, thus renovation was limited. DCLCP material successfully solved this problem. Historic inheritress is well preserved through adopting original material to renovate buildings.



**Figure 9** After renovation

### Art Consideration

Products made of decorative concrete combined with GRC appeared more than ten years ago in the form of relief in artistic decoration in the Diaoyutai State Guesthouse and the National History Museum [Figure10]. The innovation of introducing building materials into the field of art has attracted the attention of many experts and scholars, who used to see sculpture works made of metal, jade and wood, but never concrete, more importantly, previous art is the so called 'fine art' represented by 'imperial power art' and 'celebrity art', while 'decorative concrete art' is more close to real life and nature. This art not only embodies in materials, but also in the creativeness.



**Figure 10** Decorative sculpture, landscape and relief

Then the artistic atmosphere was brought into the field of cladding panels, more and more architects began to get excited and try to use it. Mr Jinqiu zhang, academician of Chinese

Academy of Engineering, appraised the Daming Palace project, 'art exists everywhere, a large industrialized cladding panel turned into expressive architectural art work in the hands of Mr Baogui Zhang, this is really amazing'. An interesting thing is that this kind of decorative concrete product was invited into the arts and crafts show in successive Beijing Cultural Creation Industry Expo. They were displayed next to the ivory and jade sculptures, however they were not short of low-key luxury at all. It is regarded by the public as a 'general industrial art'. Labeled by art, decorative concrete constantly changes its style, and actively participates in the architect's creation, so completed is not only a project, but also an art work.

## **BUILDING MATERIALS HELP ACHIEVE THE BEAUTY OF ARCHITECTURES**

According to the chief architect of Hebei Provincial Architectural Design Institute, Mr Weibing Guo, materials play an important role among the factors to accomplish a successful architecture. For instance, glass used in the Crystal Palace during the first World Expo shocked the world when the architectural world was still dominated by traditional classic style. Another example is the controversial Eiffel Tower, which was also a surprise when it appeared in the centre of a glorious empire. It was also discovered that, at the 2010 Shanghai World Expo, the exploration of materials plays a big role in the design of the venues. Thus for any successful works, the importance of materials cannot be neglected. It is fair to say that the architectural design cannot be ahead of the time, but it is facing the future. It seems that Baogui Stone meets the psychological demand that architects want to follow the nature and transcend dreams. Expressive building materials enable the the spirits that architects transferred become vivid.

Mr Jingtang He, academician of the Engineering Academy and the designer of the China Pavilion at Shanghai World Expo, says that choosing materials is very import to express the intention of architects and the theme of the architecture, the architectural creation shall reflect the harmony of regionalism, culture and epoch. What the architect completes is a piece of work, while as a material supplier, what Baogui Stoneart completes are also works, this is highly commendable. Baogui Stoneart continues developing the material whilst keeping close contact with architects. It should be advocated that building material supplies should regard their materials as a work, a thought or an art, not just a product.

Another academician of Chinese Academy of Engineering, Mr Kai Cui, has put forward the following, a specific material shall be used in a specific environment hence, achieving an interdependent relationship between the local architectures and materials. Architectures shall keep close to themselves, to environment and to local region. Products of Baogui Stoneart mingle with the characteristics of the nature very well. New ideas are being generated continuously through endless innovation and special manufacturing process. Baogui Stoneart individualized large building with a large scale production of building materials. We have received lots of inspiration from his innovation. I personally think his work corresponds to the currently popular creative industry, thus I prefer to call Baogui Stoneart 'Creative Workshop'.

Baogui Stone is a live material, which can express ideas and transfer the power of nature. There are plenty of project cases to prove this. In the National Grand Theatre concert hall, the sculpture-like ceiling with a tension of flow and exquisite finish hits the visual nerve of architects; In Erdos Dongsheng Stadium, the reflection of light creates mysterious change on the large cladding panels [Figure 11];



**Figure 11** Erdos Dongsheng Stadium

In Xi 'an Datang West City Museum, it reveals its natural and earthy characteristic, creating a sense of history by modern technology; In Tianjin Jixian Geological Museum, it seems to grow there, sending out the essence of harmonious and roughness; In the school buildings in Beijing University, its mouldability interprets a rigorous, unique, mathematical beauty of structure.

Various projects using Baogui Stone as cladding are show in Figure 13 to Figure 22 in the Appendix.

The dribs and drabs stories related to architects accomplished both architects' creativity and the charming life of Mr Baogui Zhang. The latter is liked by architects because he shares the mutual ideas and values with architects in a persistent and unique way.

## **STORIES ABOUT BAOGUI STONE**

Like its inventor, Mr Baogui Zhang, Baogui Stone is endearing, especially to architects. This material opens a window of inspiration to the architects, helping them create new ideas and recognition about materials and have better manoeuvrability and higher flexibility to design.

Due to the limitation of the material itself, natural stone, no matter on the high-end or low-end, sometimes cannot fully express the architectural connotation that the architect envisaged. After frequent contacts with this bespoke decorative concrete cladding material, some architects named this materials 'Baogui Stone'. The presence of 'Baogui Stone' changed the original cognition of architects. Although natural stone has certain texture and detail, it is lacking in flexibility. The most feeling from 'Baogui Stone' is that it is not just a novel material that Mr Baogui Zhang developed, moreover it's a thought and a spirit of Mr Baogui Zhang, which can stimulate the creativity of architects and inspire each other.

Baogui Stoneart processes waste into useful material, at the same time turning the ideas of the architect into art reality. The non-stop exploration and innovation is the vitality of Baogui Stoneart and also the reason they are liked by architects. In the final analysis, the culture merit is where their value comes from and this material is particularly suit for buildings with deep cultural connotation, for example, cultural buildings and memorial buildings. This material enriches the expressive force of buildings no matter taking the form of symbols or cladding finish.

The career of Mr Baogui Zhang has increased the vocabulary of architectural language and enriched the architectural context, this also indicates the development potential of the material is very promising.

Serving for the architectures, expressing itself via architectures, walking on the path combined with cultural creativity and sustainable economy, Baogui Stoneart has been through 26 years' development under the guidance and encouragement of architects.

The inspiration and expression of Mr Baogui Zhang's concrete cladding panel comes from his cognition on the mouldability of stone, cement and concrete, thus the decorative cladding panel he developed possesses a special character and a unique spirit. As a crossover building surface finish medium, Baogui Stone gained popularity among architects through its tailored and individualized products based on the mass production of traditional industrialized precast and installation. Pushed by new design ideas, Mr Baogui Zhang draws the deserted power of nature and developed a poetic concrete cladding material, which can be either as charming as silk or as rough and tough as rocks.

The changing and magic expression of concrete cladding under Mr Baogui Zhang's hand inspires architects' imagination, and even makes them immersed in the selection of materials and construction. There is thinking of construction logic and reality in this process. This ongoing design and manufacturing process makes Baogui Stoneart factory more like an experimental base, where all the possible and impossible, expected and unexpected could happen, this dynamic R&D and re-creation process attracts architect. At present all the design institutes have established good cooperation relationship with Baogui Stonart. Not only as working partners, Baogui Stoneart also makes friends. Baogui Stoneart and architects inspire and affect each other during the cooperation, which promotes the development of the industry and provides infinite possibilities for the fusion of building materials and architectures, culture and art, environment etc.

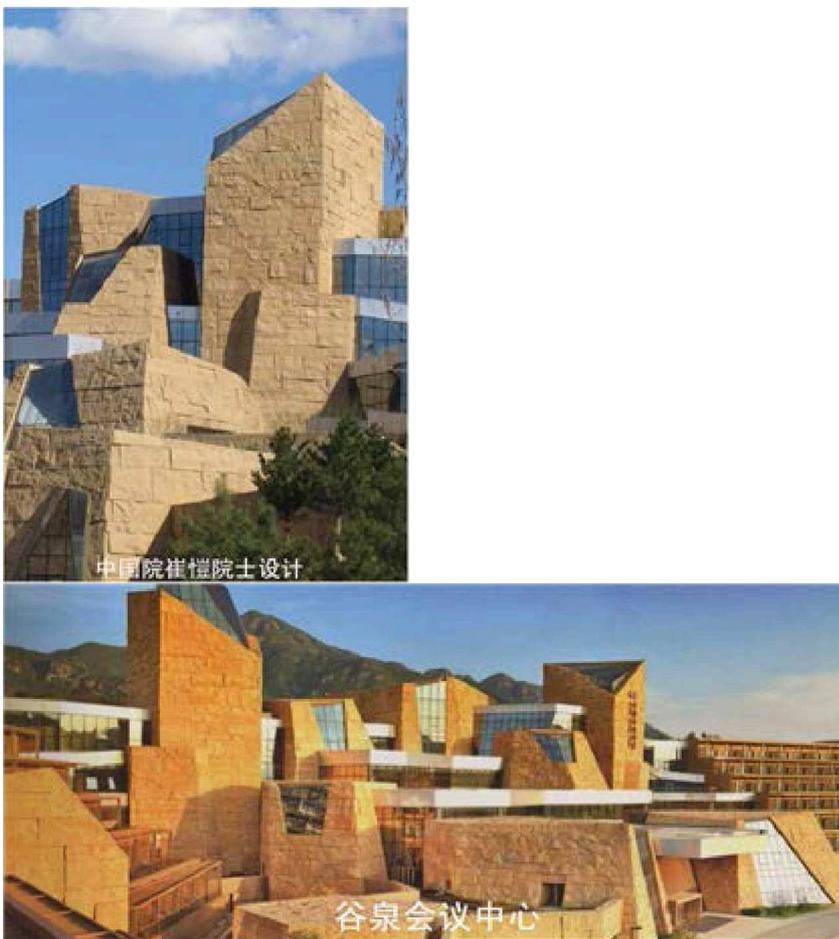


**Figure 12** Making friend with architects (2012 Spring festival in Baogui Stonart)

**APPENDIX. VARIOUS PROJECTS USING BAOGUI STONE AS CLADDING**



**Figure 13. World Grape Expo Garden**



**Figure 14. Guquan Conference Centre**



**Figure 15.** The new Beijing Youth Palace



**Figure 16.** Chengtong Mountain Museum



**Figure 17.** Yushu Museum



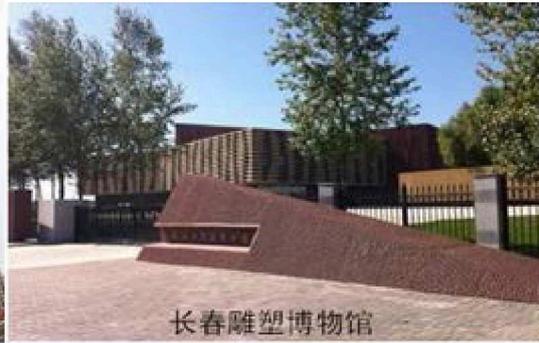
**Figure 18.** Office block in Shanxi Province



**Figure 19.** Library in Beijing Second Foreign Language University



**Figure 20.** Jia Pingwa culture and art gallery



**Figure 21** Changchun Sculpture Museum



**Figure 22** Education museum in Shanxi Normal University