11 Application of GFRC in Expo. Construction

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ABSTRACT

This paper systematically introduces GRC`s deformability by different moulds, its rich textures and the panel structure loading system etc.
How we can fully take use the advantage of GRC and its mechanics in order to apply it in modern architecture at maximum. A. To realize the Architect`s creation inspiration. B. To show the maximum value for the investor. C. To beautify the city zoology environment.

GRC`s Advantage in the construction curtain wall:

1. Rupture strength>18Mpa, five times of general concrete and 2 times of nature stone;
2. Rich texture and color;
3. Light in weight but with high strength and quick installation;
4. Suit for the non-linear modern construction and sculpture because of its deformability;
5. Resistance to chemical attack, the alkali resistant glass fiber is not like the steel in the concrete which is easy to be rust;
6. High weather resistance, it can be used in all different weather environment;
7. GRC is A class non-combustible material;
8. Sealed by photocatalysis sealant with self-clean function.

CHAPTER I

Application of GRC Double Curved Panels for Non-linear Construction

1.1 Tianjin International Cruise Home Port Passenger Transport Building Project - Brief Introduction

Photos: TJ-Photo 1,TJ-Photo 2

Tianjin International Cruise Home Port Passenger Transport Building is typical dynamic modern construction, it is the biggest transport harbor port. The construction area is about 60000m^2, with the functions of international passengers clearance, and commercial shops. The main structure with 3 storeys, partially with 5 storeys, each floor with 5.5m-6.5m height, construction height is about 38m. Main building façade all decorated by glass and GRC double curved panels.

Among the façade decoration, the top and the places between floors are 42000 m^2, the size of a single panel is 7.2m*4m. The quantity of the panels is 3000pcs, each panel with 1800kgs weight. Each panel with steel back support. This is the first time for GRC to be applied in modern digital component, and developed a new area for GRC curved curtain wall panels.

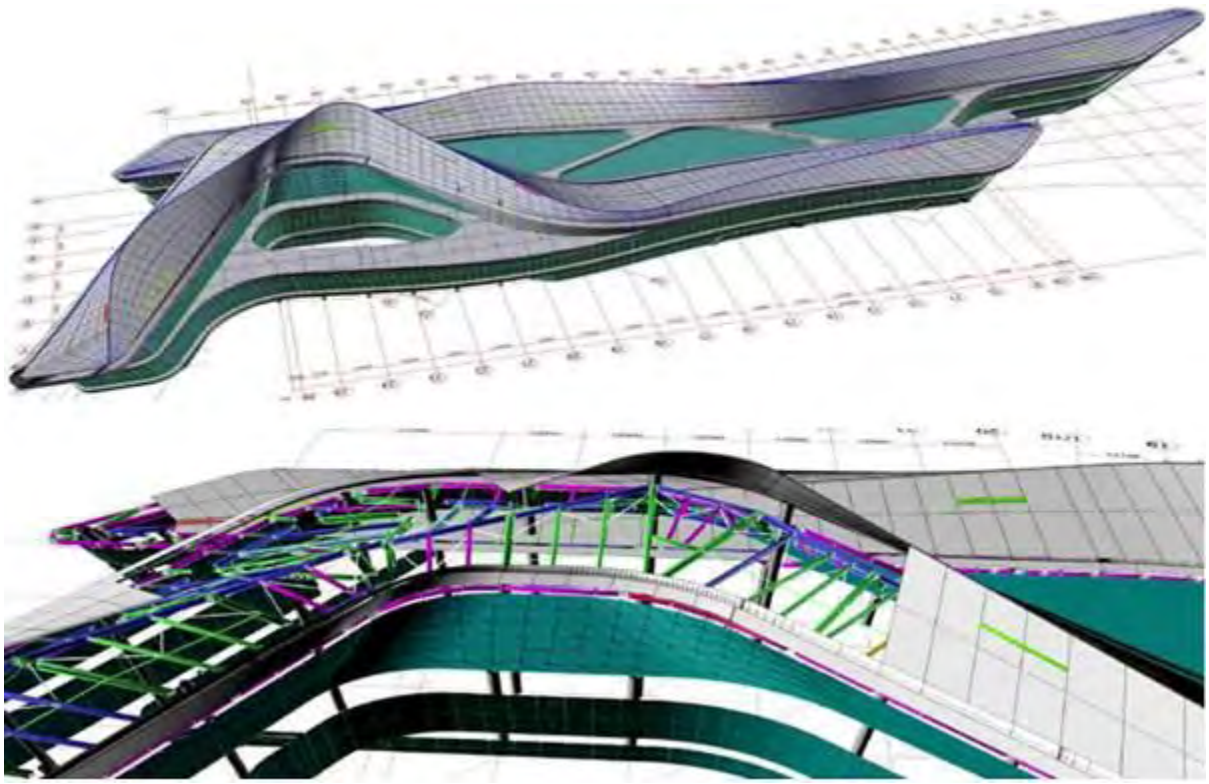
1.2 Architectural shape and curtain wall design

1.2-1 Curtain wall design

Tianjin International Cruise Home Port Passenger Transport Building is a whole steel structured building with the concept of green environment protecting and continuous development.

The designer`s inspiration is opening a Silk Sea Route for China, the whole building looks like two silk ribbons waving at the sea shore, in perfect harmony with the sea, up and down. The main building with full of tension and speed sense, showing the good vitality in the port. This design got the First Prize in April of 2009 on China First BIM (Building Information Model) Architectural Design Contest held by the world famous digital design software company named Autodesk and China Architecture Institute.

Photo: TJ-Photo 3



This is the first design for the double curved construction to use the big size GRC panels. It has to be perfect combination for the digital components and GRC materials, there was no precedent in the world. The detailed design mainly by the supply factory design team, after receipt of the structure shop drawings and 3 D Rhino model shop drawings (See Photo C) from China Construction, the factory design team start to work for the installation joints and the panels separation, panels shape design and steel back support design, product shop drawings and calculations etc..

1.2-2 RHINO software application

The double curved construction, the shapes changes continuously, the traditional 2D shop drawing becomes as a sketch or an index. The structure, electrics, air-conditioner etc. cannot be discussed and precisely arranged on the base of 2D shop drawings, and it is impossible to make the accurate construction shop drawings quickly for the materials and the construction, either.

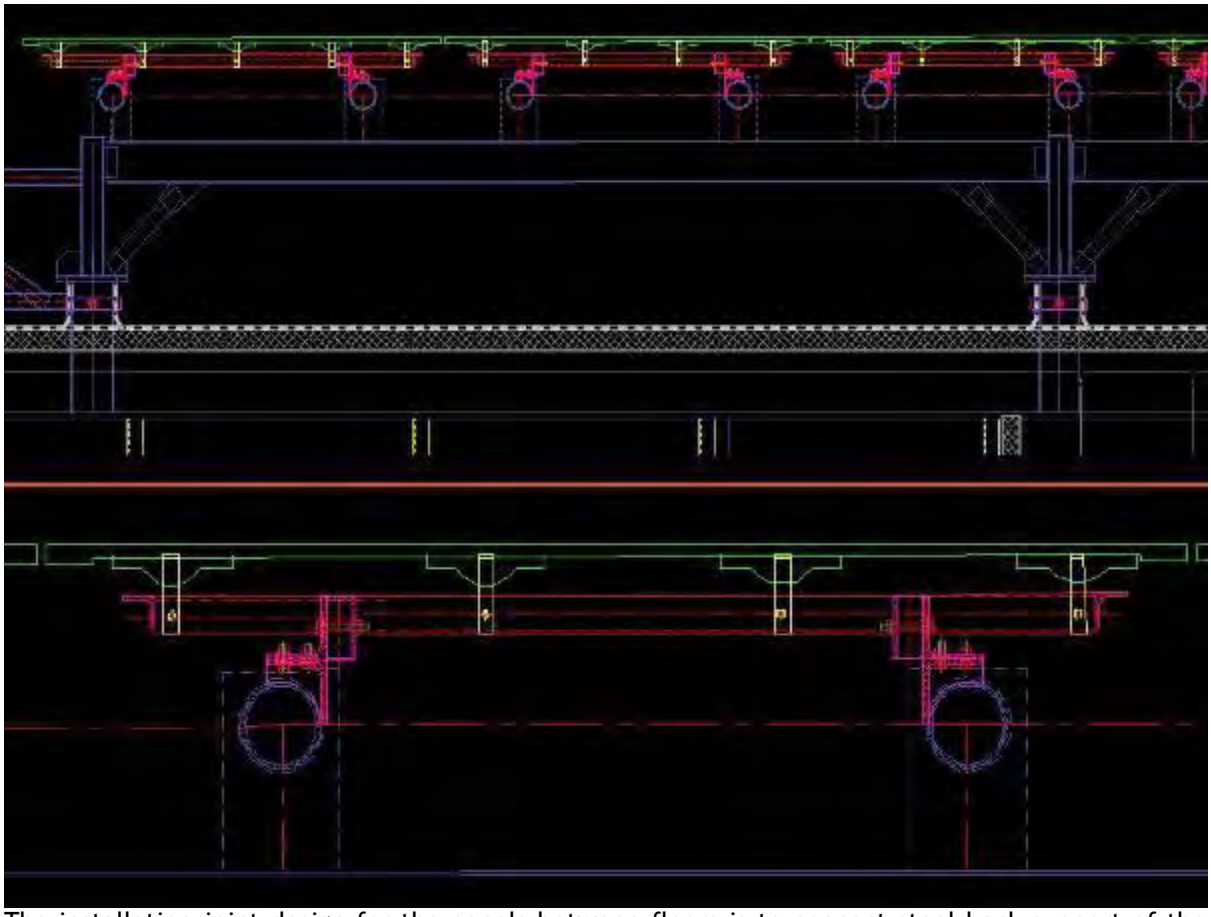
We use 3D design software as a main control during the production, not only as an access to the design. We used RHINO software to design and control, the most important is that 3D model is more accurate than 2D and more effective, too. Such as glass curtain wall and exterior GRC, 3D model can be used directly to instruct the production and construction

1.2-3 Curtain wall panel joints design

The installation joint design, roof panel system made by the main truss purlin and GRC steel back

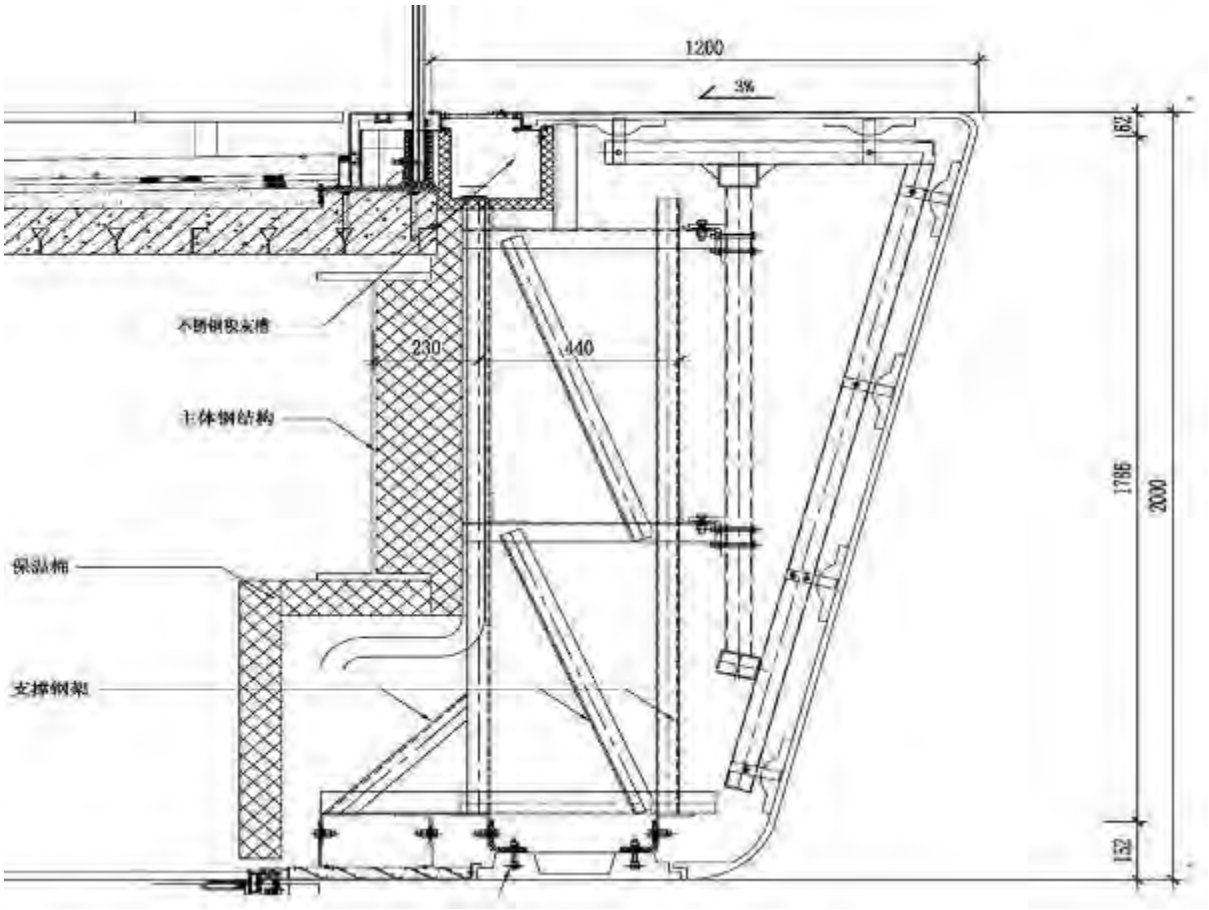
support connected by bolts

Photo: TJ-Photo 4



The installation joint design for the panels between floors is to connect steel back support of the GRC panel to the installation keel by bolts.

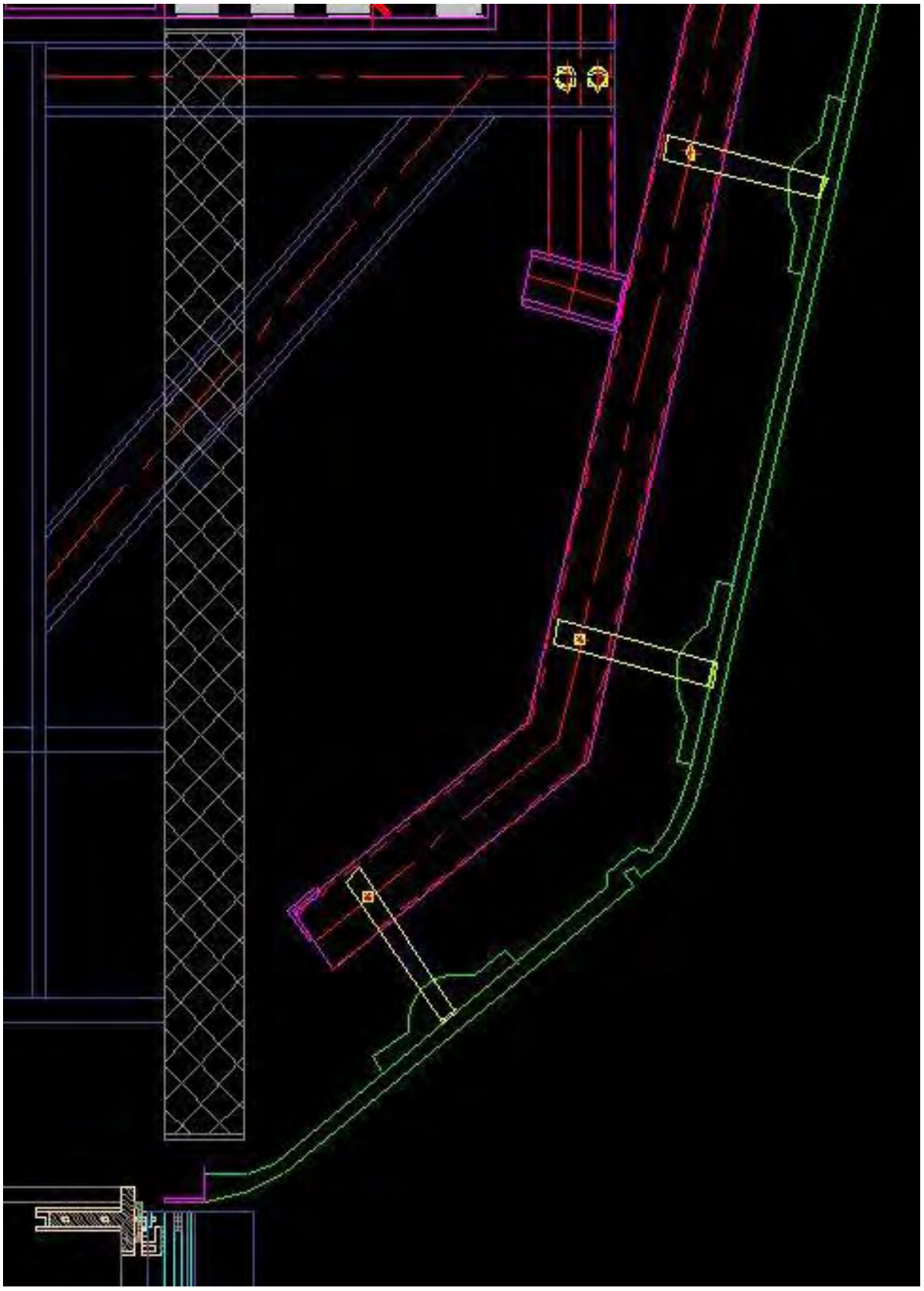
Photo: TJ-Photo 5



1.2-4 Steel back support design

GRC panel and steel back support is connected by a flexible L shape to prevent the damage from the stress concentration.

Photos: TJ-Photo 6、TJ-Photo 7、TJ-Photo 8



1.3 GRC curtain wall fabrication

1.3-1 Raw materials

Higher than standard of BS EE 1169:1999 to be followed for the raw materials of GRC panels and procedure of production. The white degree of white cement is over than 90%,the strength is 52.5 grade, the aggregate is fully first class silica sand whose Sio2>96%, the fiber glass is AR with more than 16% Zro2.Additionally,to meet the requirements of GRC panel the long term durability and mechanical performance, we added some high quality additives from Rohm Haass, BASF and Sica.
All raw materials meet the requirements of USA PCI regarding GFRC raw materials standard. The rate of the materials tested many times, the concrete to the sand is 1:1,water to concrete is 0.38:1,the content of fiberglass is 5%. The products can meet the British Standard with acceptable color and texture. Steel back support all welded according the welding specifications, then wholly hot dip galvanized to guarantee the thickness of the zinc coating to be 70um for 50 years corrosion control

1.3-2 Production workmanship

During the production for Tianjin project, because of the special shapes of the products, the factory met a lot of difficulties. First the moulds making, the double curved shapes control, how to control the product size and the joints? Second, how to fix the installation joint for the big size component? After some research, the digital 3D technology introduced into the factory, the difficulties for mould making, product size control, joints problem were all solved. The tolerance of complicated double curved panels is within 3mm under the control by 3D. Steel back support installation joint tolerance is controlled well within the adjusting scope of connecting brackets. By using new technology and the machinery, the demoulding, overturning, transportation and hoisting were all solved.

Photo: TJ-Photo 9 (the roof after demoulding then overturning)

1.3-3 Quality control

The factory is under the management of ISO9001 quality control system and PCI-130 standard. The Quality Control Department was set up, there were about 10 QC persons who were responsible for

the raw materials inspection, the moulds and process and the products quality control, high level lab was set up, every day, each shift, their products were checked by samples. All the product files were set up, each GRC component with its own ID code, easy to be traced. Because of the complete quality control system, the product quality is guaranteed.

1.4 GRC curtain wall panel installation

1.4-1 Roof panel installation

First, set up the purline system on the roof, then hoist the GRC roof big panels, finally, locate and adjust the panels by the help of measuring instruments.

Photo: TJ-Photo 10、TJ-Photo 11

1.4-2 Interbedded panel installation

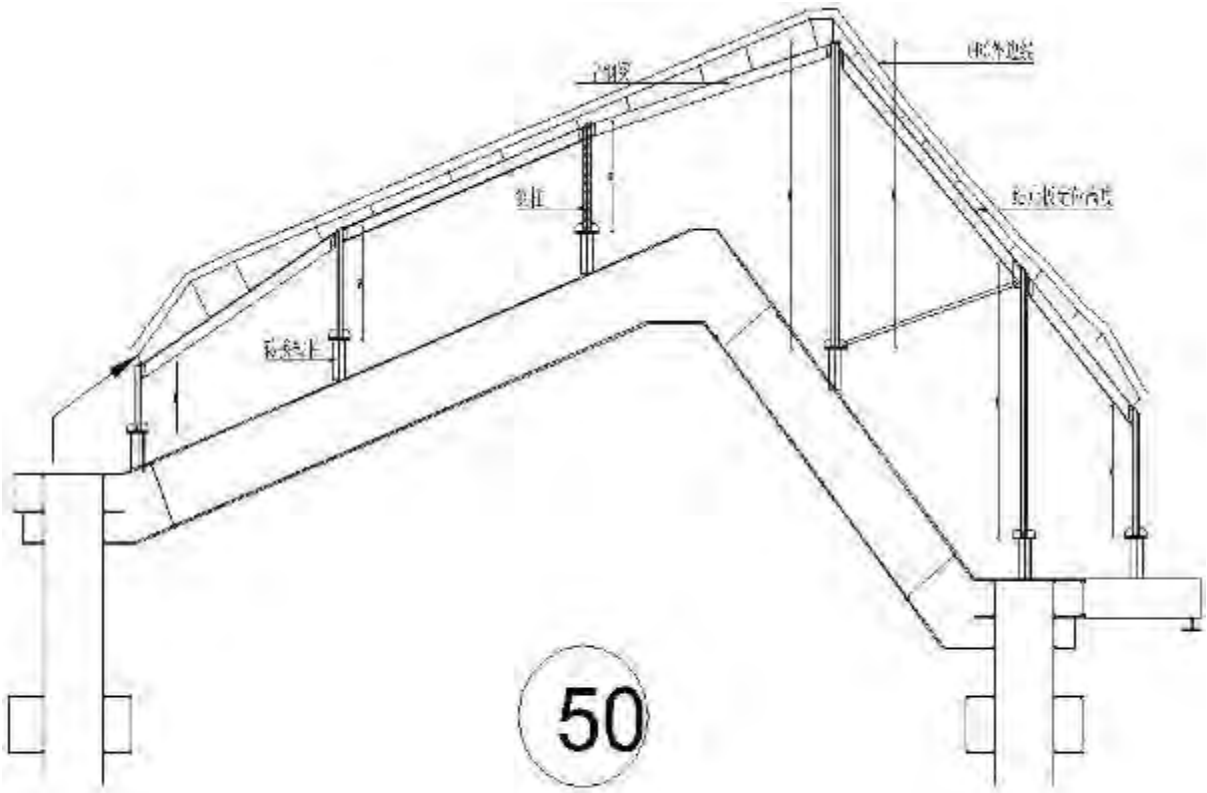
First, weld the steel back support to the main steel structure, then hoist the panel and connect the bracket, after a certain area ready, then adjust partially to guarantee the connecting joints harmoniously.

Photo: TJ-Photo 12、TJ-Photo 13

1.5 GRC roof support and function system design

1.5-1 Roof support style

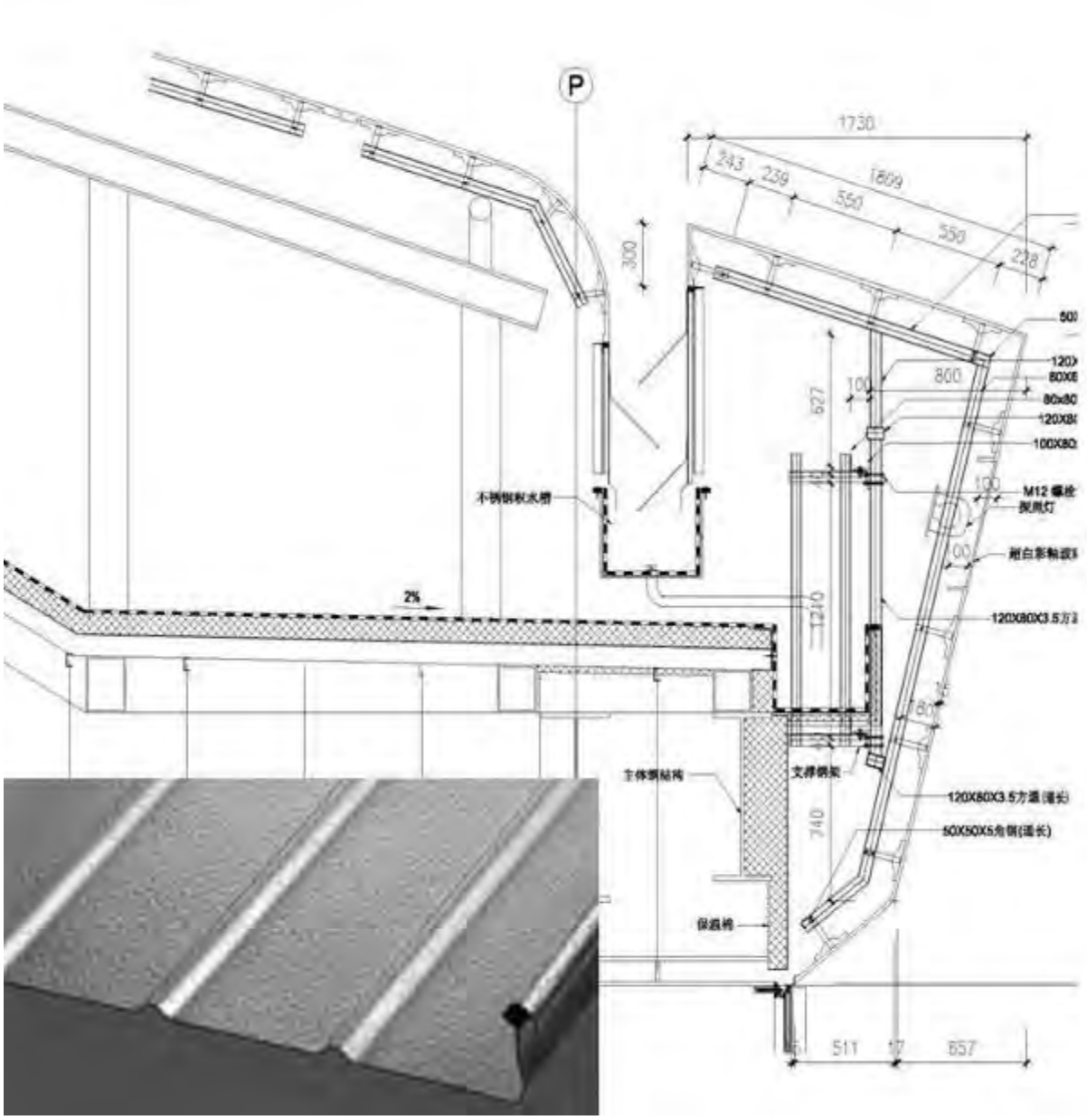
Photo: TJ-Photo 14



1.5-2 Roof function system, the materials list from the surface of GRC component to the main structure

GRC/hot-galvanized steel back support for GRC/stainless steel capillary groove/purline/support short column and trussed beam/ macromolecule coiled material waterproof layer/90-120mm insulating layer/ 0.8mm steam proof layer/ Thorium aluminum zinc plates on the type/steel keel/main structure.

Photo: TJ-Photo 15



1.6 Project completion finish and summary

1.6-1 The completion finish

Photos: TJ-Photo 16、TJ-Photo 17、TJ-Photo 18、TJ-Photo 19、TJ-Photo 20、

1.6-2 Project summary

The application of double curved GRC curtain wall big panel for Tian Jin Port project, is a great pioneering work, stands for Chinese GRC field new concept and technology development and engineering application to reach to the advanced level in the world. As the developing trend for the mordern architecture individuation and digitization, Tianjin Port as an example, new GRC curtain wall panel would cause more and more Architects attention. It would push GRC in China to develop quickly. And curtain wall system would be a new trend with the regulation of GRC curtain panel design.

CHAPTER II

GRC Application of Heat Preservation and Decoration Integration Curtain Wall big Panels in Public Stadium

2.1 Introduction for the Project of the Youth Centre, Huhhot of the Inner Mongolia

Photos: NM-Photo 1,NM-Photo 2

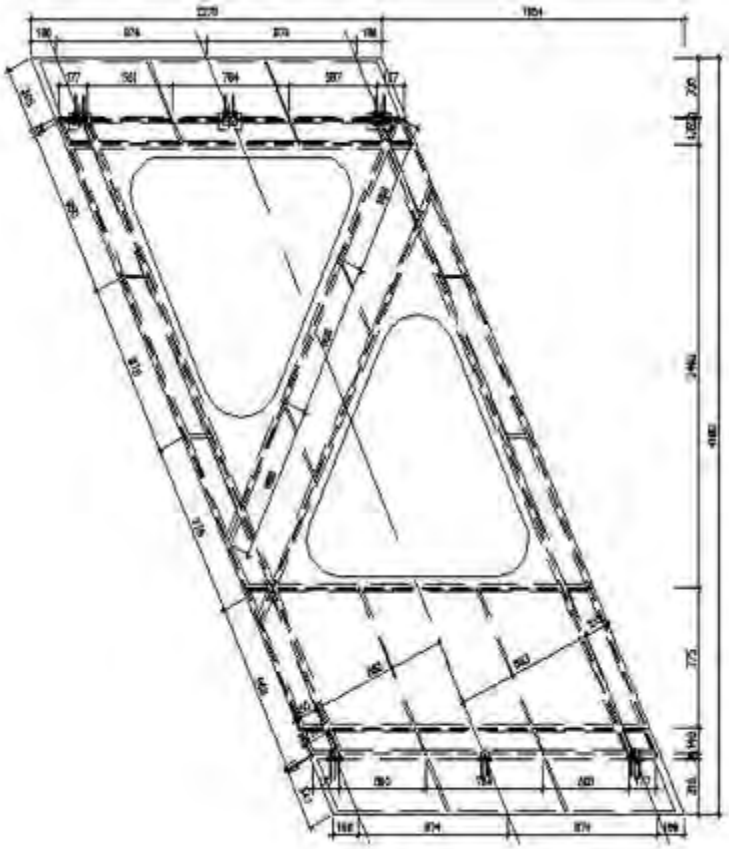
This project is a new built multilayer building. The construction concludes three main parts: a complex building, a theater and a gymnasium. There are more than 1560 sets of irregular triangle windows in elevation. The local lowest temperature in Huhhot is -25℃ to -45℃. Because of the temperature and the elevation design, GRC panel should be heat preservation and decoration integration, the glass doors and windows should be connected with GRC heat preservation and decoration panels. The total areas of the panels to be used are 26,000 m^2, the work time is 100 days.

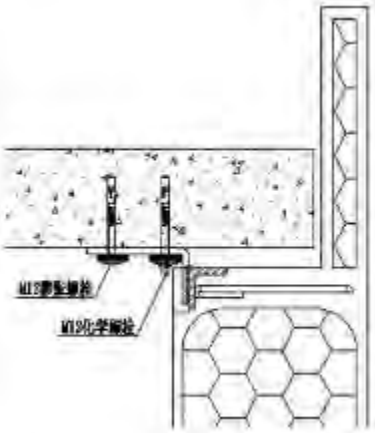
2.2 Curtain Wall Design and Panel Shape Structure

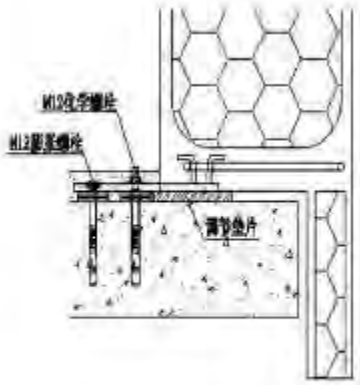
The design proposal based on the characteristic of the project, for there are lot of radius, irregular triangle windows, and heat preservation panels with the thickness of 200mm,fire proof with A1 grade, the up and down beams fixed structure.

2.1 To meet the requirements of above mentioned characteristic, we made the design directly to produce the panels with the thickness of 250mm,the width of 2.4m and the height of 4.2m, per panel with the area of 10m^2, the weight of 1.6tons,the inner part with GRC ribs and steel keels reinforced beam structure.

Photos: NM-Photo 3,NM-Photo 4






M12化学螺栓
M12膨胀螺栓
调节垫片

2.2 By calculation, we need the key data from the 3rd Independent Inspection Co., the test report says that the strength is 530kg/m^2, no any cracks, good for the breaking strength and bending strength design requirements.

Photos: NM-Photo 5,NM-Photo 6

内蒙古呼和浩特市青少年活动中心

外墙 GRC 板检测报告

检测：
审核：
审定：

内蒙古工业大学建筑材料科学研究实验中心

二〇一〇年八月二十三日

工程名称：呼和浩特市青少年活动中心教学综合楼

拉拔力检测报告

批　准：
审　核：
检　测：

报告编号：LB 2010 — 316

呼和浩特市建筑工程质量检测试验中心

2010 年 09 月 07 日

报告编号：LB 2010 — 316　　第 2 页，共 3 页

委托单位		工程名称	
测试项目	拉拔力	预生产厂家	———
试验名称	GRC 构件板材	螺栓或化学锚栓生产厂家	———
检测数据			
检测位置	预埋连接件	预埋连接件	预埋连接件
规格型号	2.5×4.9×0.25	2.5×4.9×0.25	2.5×4.9×0.25
设计强度等级	———	———	———
锚固深度（mm）	———	———	———
钻孔直径（mm）	———	———	———
锚固端破坏状态	破坏	破坏	未破坏
设计拉力值（KN）	6.25	6.25	6.25
检验拉力值（KN）	———	———	8.2
极限拉力值（KN）	17.8	20.2	———
备注			

批准：王向平　　审核：李　芳　　主检：张睿　杜晓杰

出具报告日期：2010 年 09 月 07 日　　（本页以下无正文）

2.3 GRC Heat Preservation panels Fabrication and Installation

All the raw materials for GRC heat preservation panels are GRC material, heat preservation panels, steel keels, soft mould with stone texture, GRC moulds making platform and the equipments for hoist and delivery. For this project, there are lot of radius, over size big panels and the over weight panels, difficult to move them, the work condition is very complicated with the high precise requirement, so it is so important during the process to hoist and control the joints well.

Photos: NM-Photo 7,NM-Photo 8,NM-Photo 9,NM-Photo 10,
NM-Photo 11,NM-Photo 12,NM-Photo 13

2.4 GRC Heat Preservation Panels Completion Finish

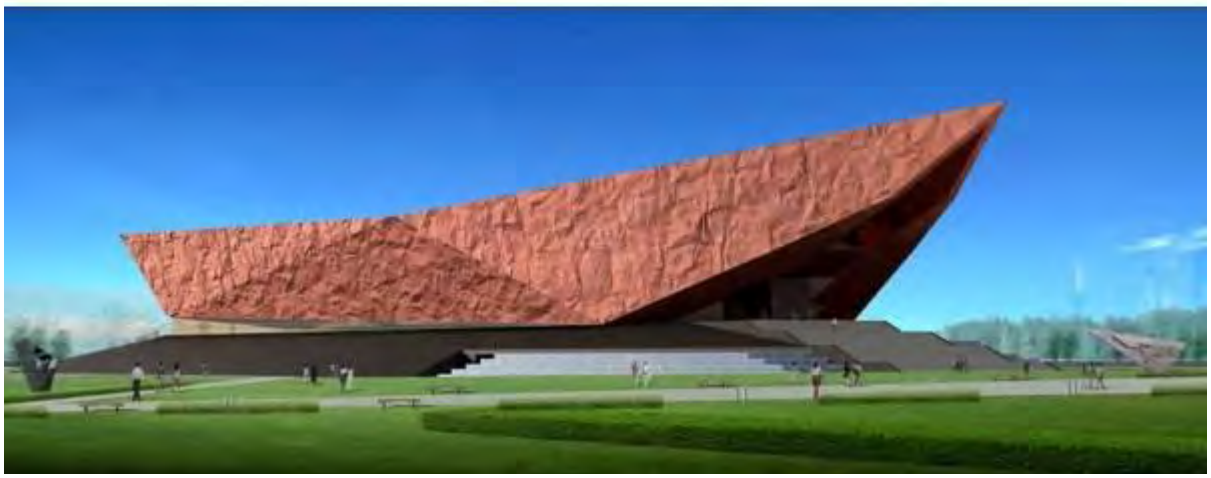
Photos: NM-Photo 14,NM-Photo 15,NM-Photo 16,NM-Photo 17


进入施工现场
禁止吸烟

CHAPTER III

3.1 GRC Application of Stone Texture Curtain Wall big Panels in Memorial Museum Wuhan Revolution of 1911 Museum Project - Brief Introduction

Photos: WH-Photo 1,WH-Photo 2



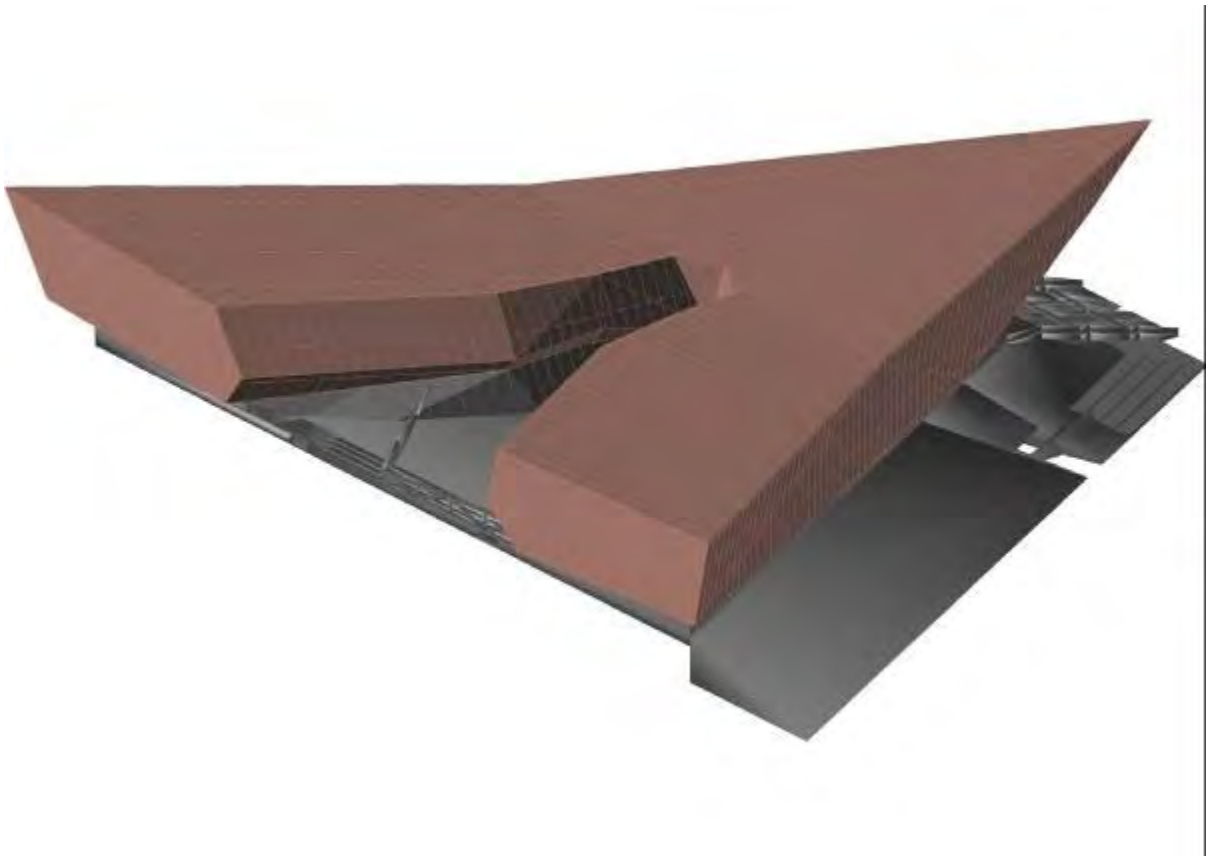
Wuhan Revolution of 1911 Museum Project, located in Wuchang district, Wuhan city. The project summarized the contribution of Wuhan Revolution of 1911, and expressed the active spirit and strong will to move forward. With the force of spearing out of the earth and shocking, and expression of the spirit of researching new and change, to be the leading person of the Revolution. The building is full of solemn. Green construction, ecological construction and energy-efficient construction concept expressed well

3.2 Curtain Wall Design and Panel Shape Structure

3.2-1 Basic Design Requirements:
Construction height is 22.5m,(the highest point of the building)/construction fireproofing is the first grade/ construction lightning protection is the second grade/ seismic fortification intensity is 6 degree / curtain wall design life is 25 years.

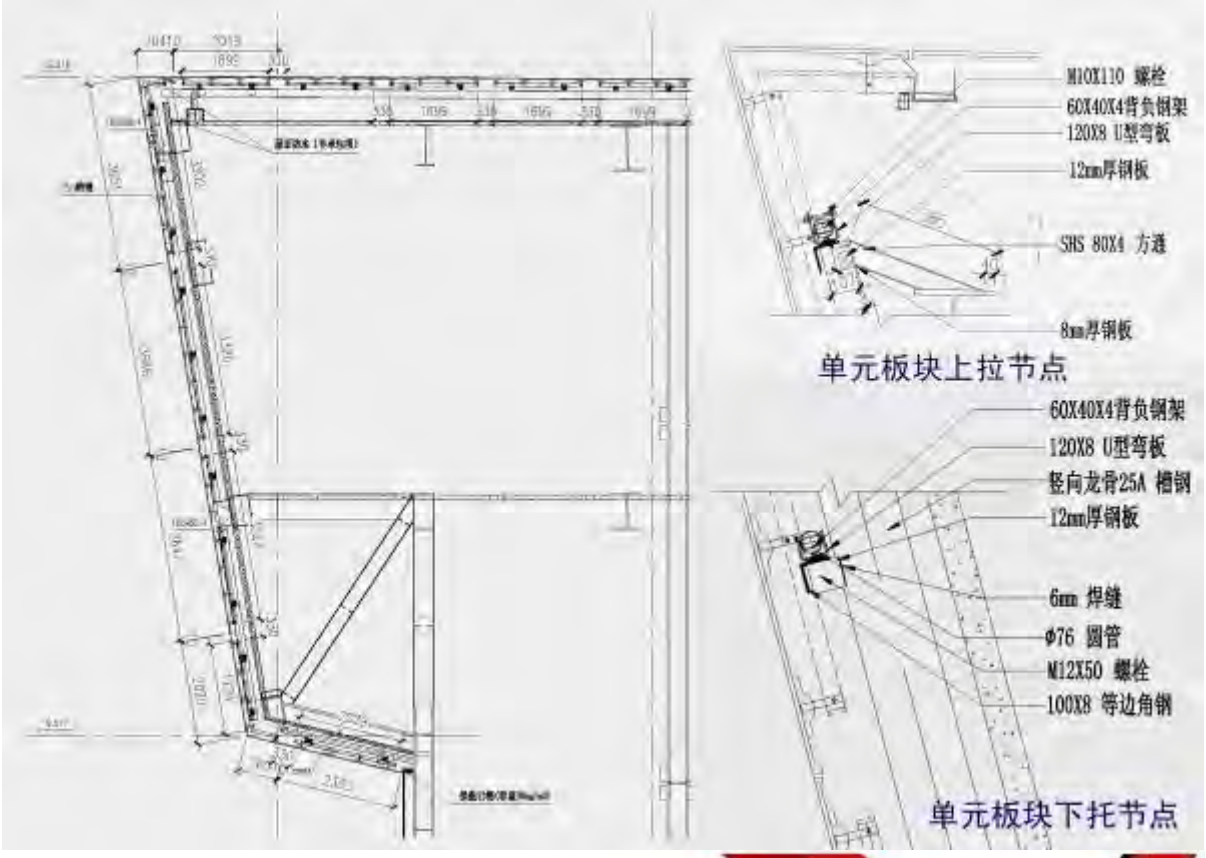
3.2-2 GRC Decorative panels` structure and main materials:
Structure type---Back support frame system
Main and secondary keels——west and east sides with channel C25, 203 & 102 round pipes, laid down according to GRC panels joints.
The roof main keel with the dimension of 200 mm x 100 mm x 5 mm and secondary keel with the dimension of 160mm x 80mm x 4mm square pipes.
The exterior panel type—GRC panel with the thickness of 15mm,the finish is dark red, with matte sealant, self cleaned photo catalysis material.

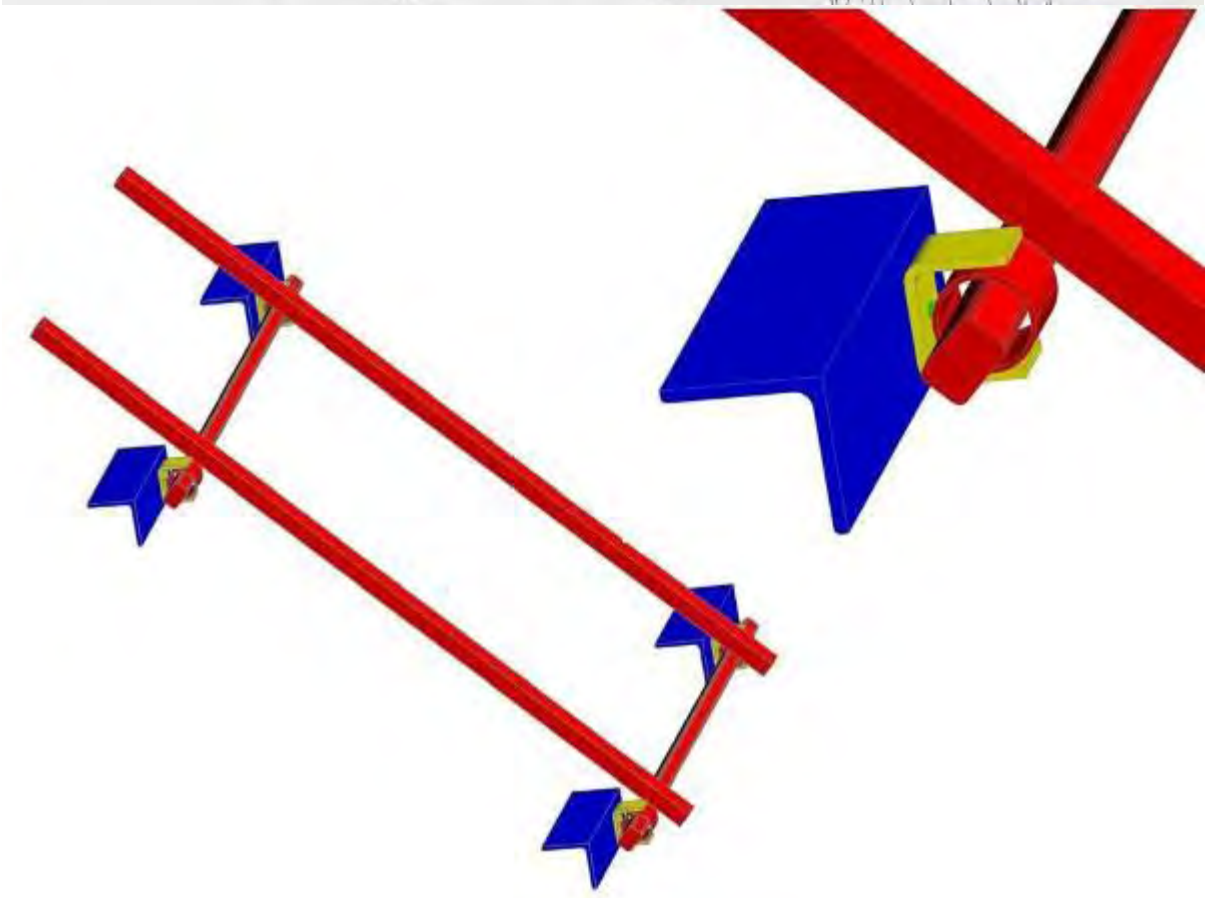
3.2-3 Rhino software was used to design the panels seams.
Photo: WH-Photo 3



3.2-4 GRC joints design:
There are GRC roof hanging panel system, GRC wall hanging panel system and GRC suspended ceiling system. GRC hanging panel and its support, anchors and attachments. The gap with the size of 10mm is good for the GRC hanging panel installation adjusted by 3D.By using the suspender to connect GRC panel to support structure

Photos: WH-Photo 4,WH-Photo 5


M10X110 螺栓
60X40X4背负钢架
120X8 U型弯板
12mm厚钢板
SHS 80X4 方通
8mm厚钢板
单元板块上拉节点
60X40X4背负钢架
120X8 U型弯板
竖向龙骨25A 槽钢
12mm厚钢板
6mm 焊缝
φ76 圆管
M12X50 螺栓
100X8 等边角钢
单元板块下托节点



3.3 GRC Curtain Wall Panels Fabrication and Installation

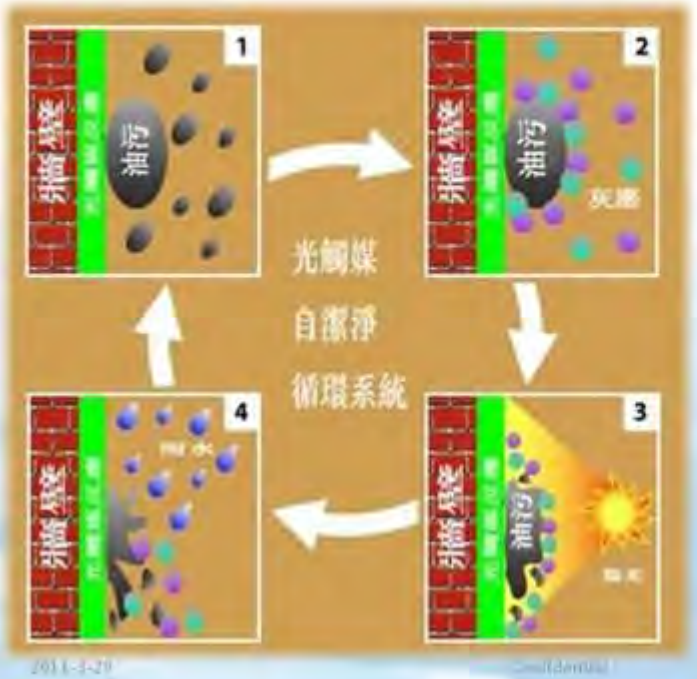
Photos: WH-Photo 6、WH-Photo 7、WH-Photo 8、WH-Photo 9、WH-Photo 10

3.4 GRC Sealed by Photocatalysis Sealant and the Texture after Installation

Nano TiO2 as a photo catalyst to be used to GRC, makes the concrete product clean and shinning finish for long term, and protects the environment. Because of this the concrete product will have its own better future, with more economy and continuous development. It provides the Architects another way to design and construct real “green” and beautiful concrete buildings.

Photos: WH-Photo 11,WH-Photo 12,WH-Photo 13,WH-Photo 14

自潔淨循環



當物體之體積微小到1至100納米，基於量子效應，其很多特性會出現變異，物體於宏觀單體原子時特性完全不同。

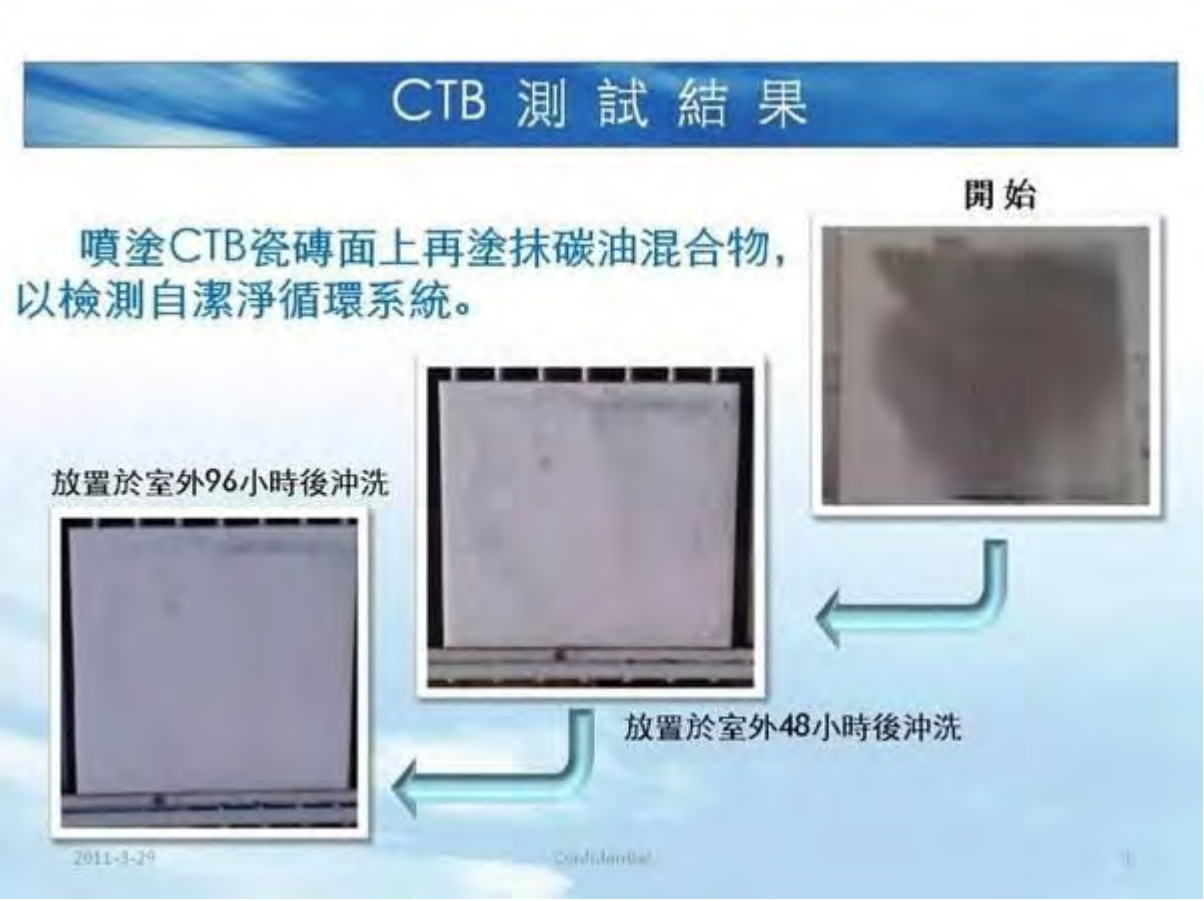
納米技術的最終目的是通過改變物體之體積到納米級別，改變物體物理及化學性能特點，生產有特殊功能的產品。

納米（英语：nanometer，簡稱nm），字首nano在希臘文中的原意是「侏儒」的意思，指1米的十億分之一。

1,000,000,000纳米 = 1 米（m）

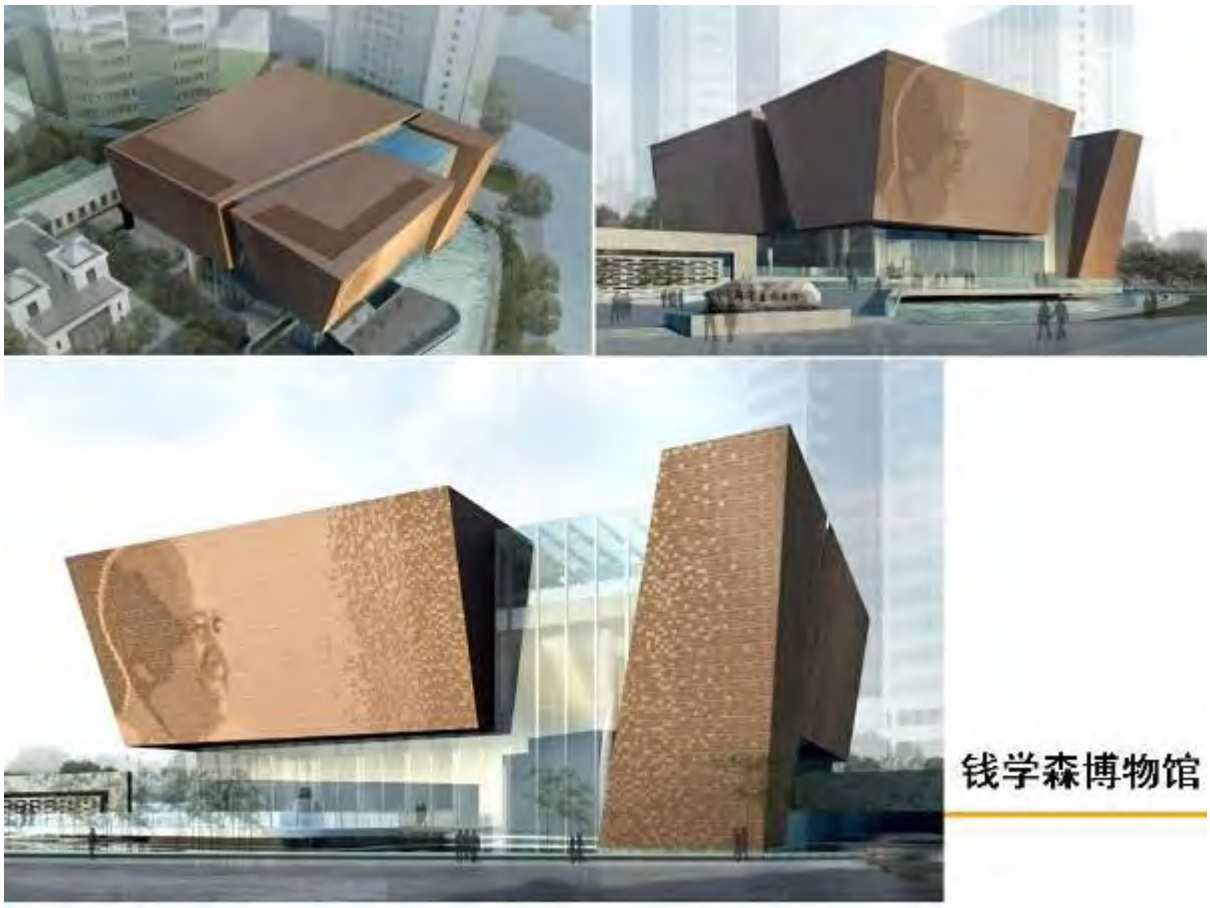
1,000,000纳米 = 1 毫米（mm）

1,000纳米 = 1 微米（μm）



CHAPTER IV
GRC Application of Human Image in Relief Wall

4.1 The Father of Missile in China, Mr. Qian Xuesen, whose Museum Project Brief Introduction
Signed by Chinese Leader Mr. Hu Jintao, Qian Xuesen`s Museum will open in Oct, 2011, meanwhile for the centenary of the birth of the Father of Missile in China, Mr. Qian Xuesen.
Photo: SH-Photo 1



4.2 Human Image Curtain Wall Design and Panel Shape Structure

Mr. He Jingtang, the main designer for Chinese Museum of Shanghai Expo, is in charge of the design for this project. The project takes Mr. Qian Xuecen`s gentle and hardy image as the background of façade. GRC curtain wall panels with exposed sand stone texture with sculpture workmanship, by the texture of different density and height to express the visual image. The designer wants to reflect Mr. Qian studying missiles in desert, under such bad natural condition, still keeping his gentle and hardy personality.

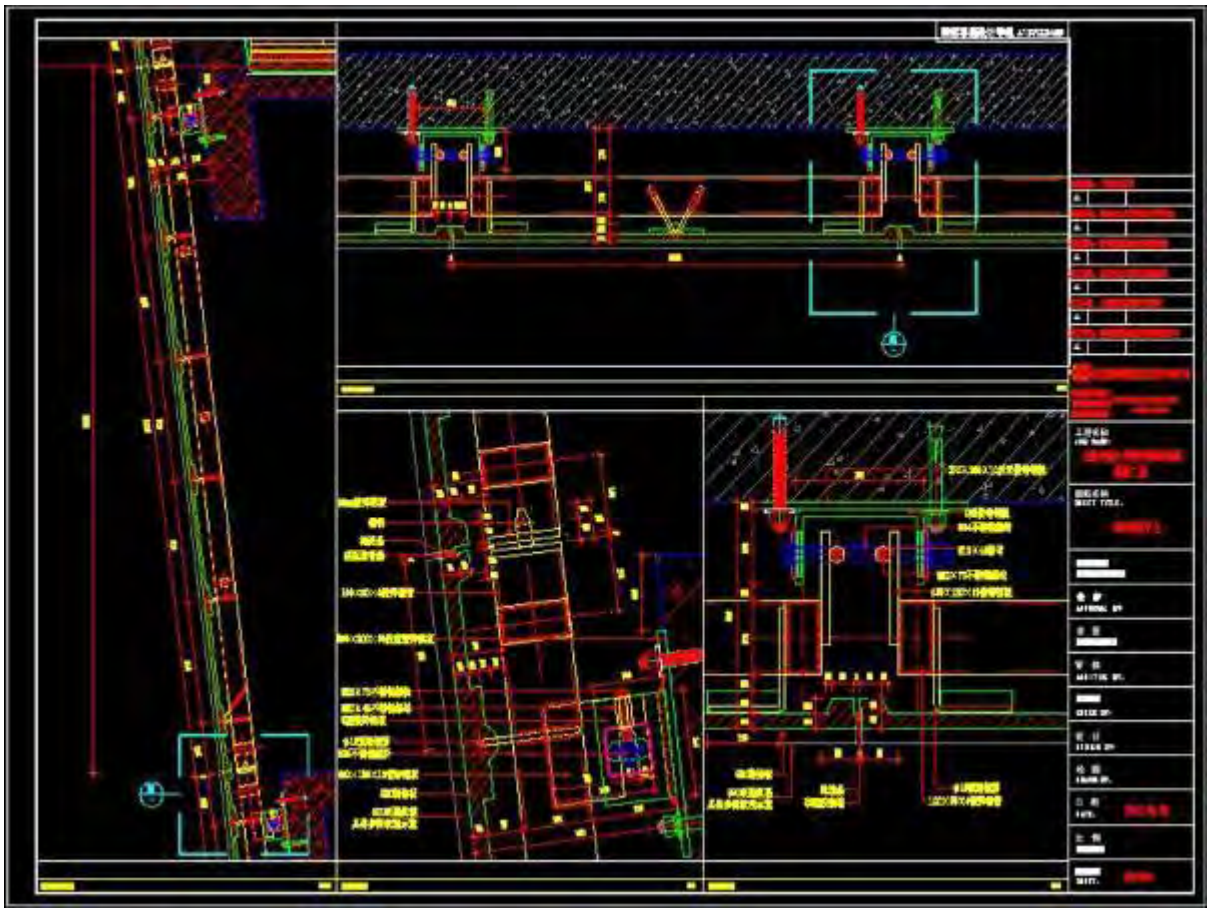
Photos: SH-Photo 2,SH-Photo 3,SH-Photo 4

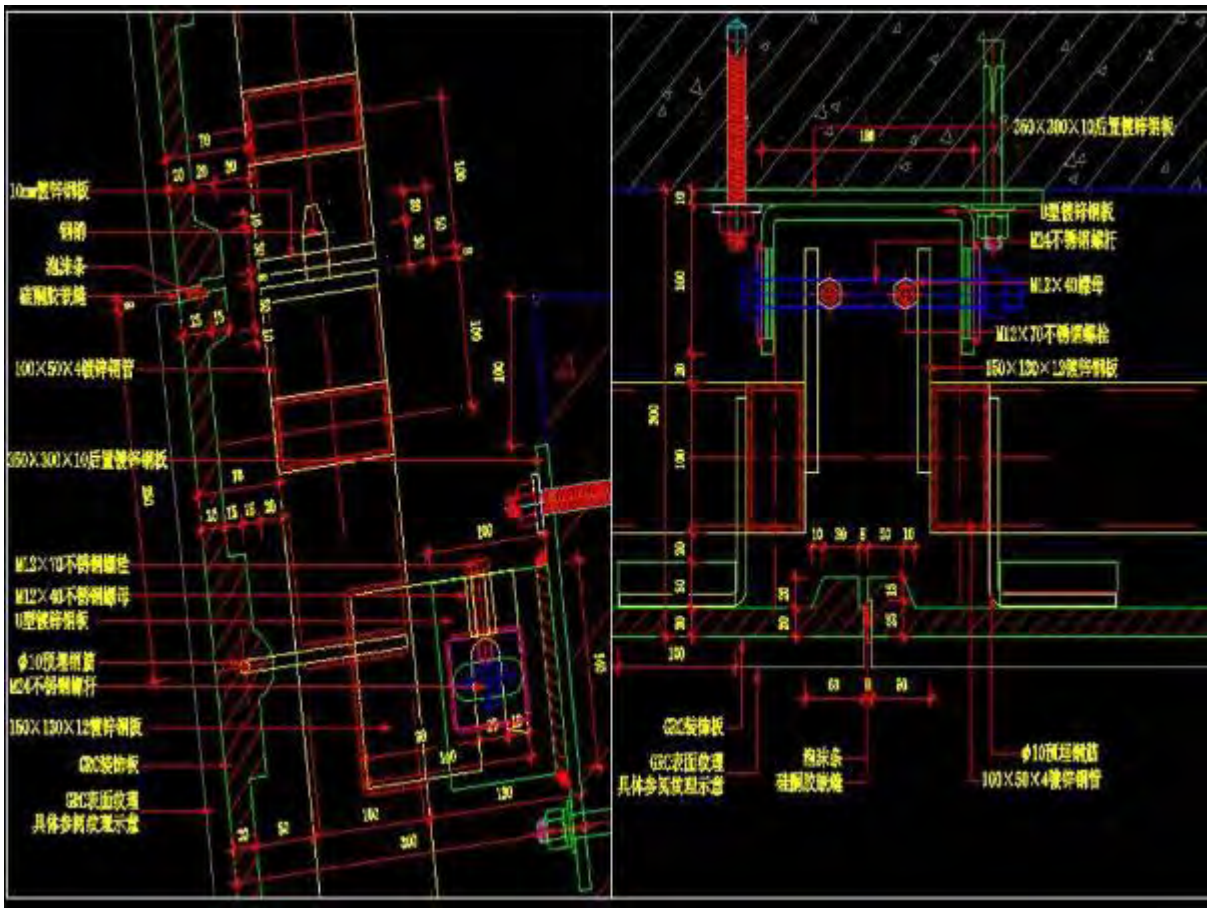

钱学森博物馆产品


钱学森博物馆

4.3 Curtain Wall Panel Installation Joints

Photos: SH-Photo 5,SH-Photo 6



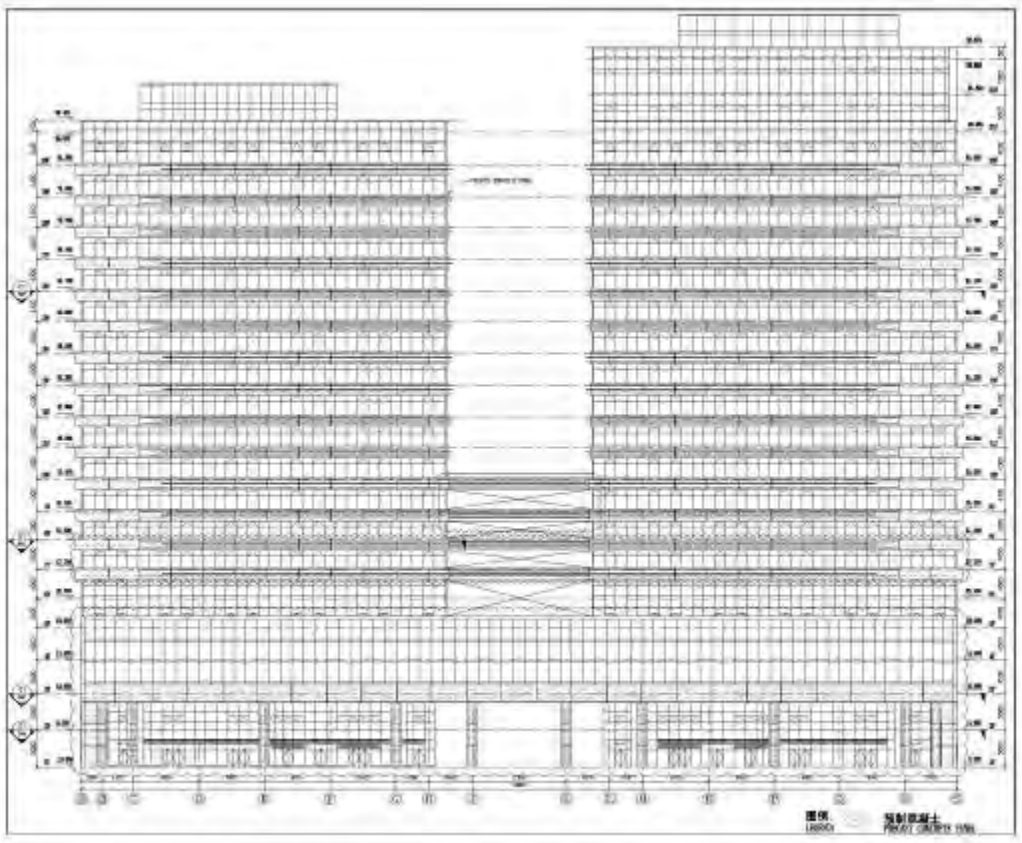


CHAPTER V
Decorative Concrete Projects

5.1 Guangzhou Gaode Center Project Brief Introduction

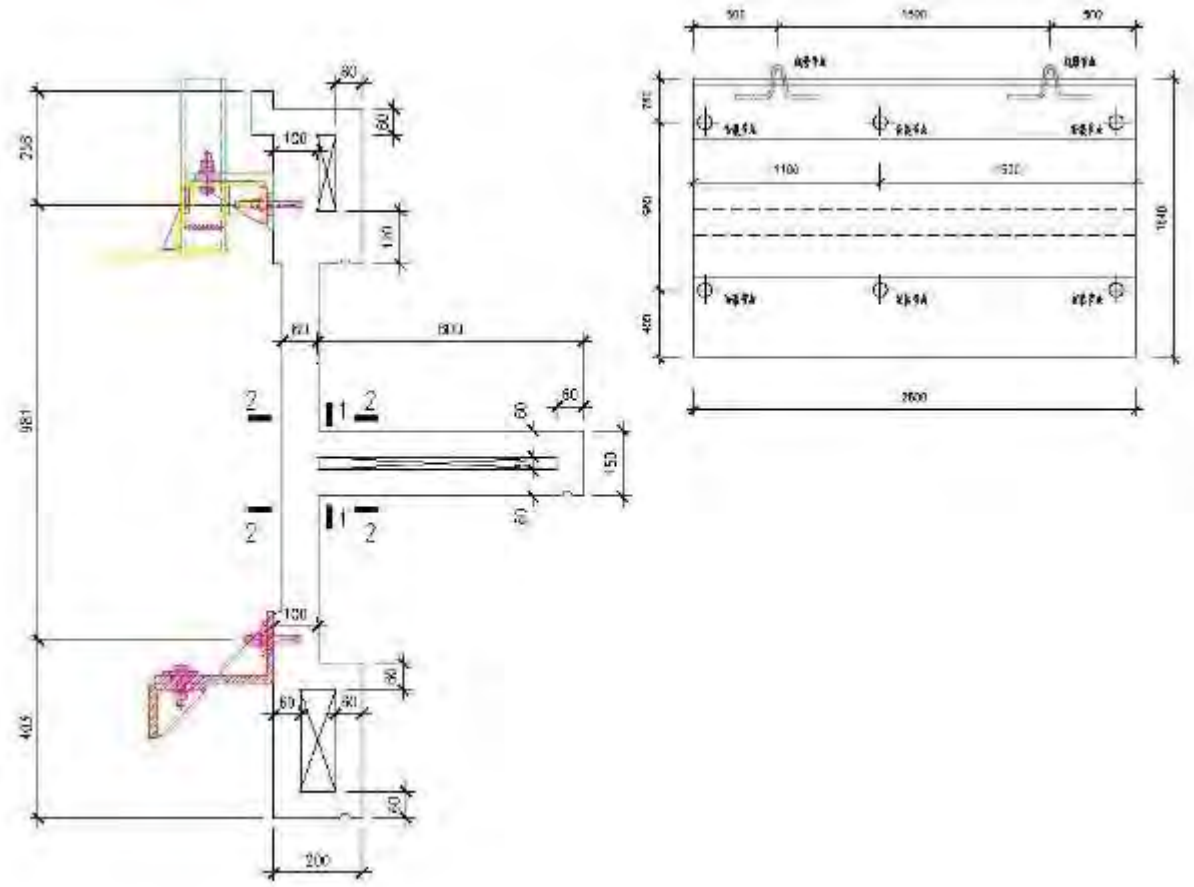
Guanzhou Gaode Center，located in the center of Guangzhou city near Zhujiang Double Towers. With the application of the steel concrete hanging panels, the height of the peak is 82.3m, made by steel concrete precast panels. All panels with the same height of 1.63m, the length of 4.5m.

Photo: GZ-Photo 1



5.2 Decorative Concrete Component Design

Photo: GZ-Photo 2



5.3 Decorative Concrete Component Fabrication

Photos: GZ-Photo 3,GZ-Photo 4

广州高德中心工程

广州高德中心工程

5.4 Decorative Concrete Component Installation

Photos: GZ-Photo 5,GZ-Photo 6

广州高德中心工程

CHAPTER VI
GRC Decorated the First Class Project in the World

6.1 Venetian Macau Project Photos Show
Photos: AM-Photo 1~10

GRC2011
Istanbul


VENETIAN MACAU P1


VENETIAN MACAU P1

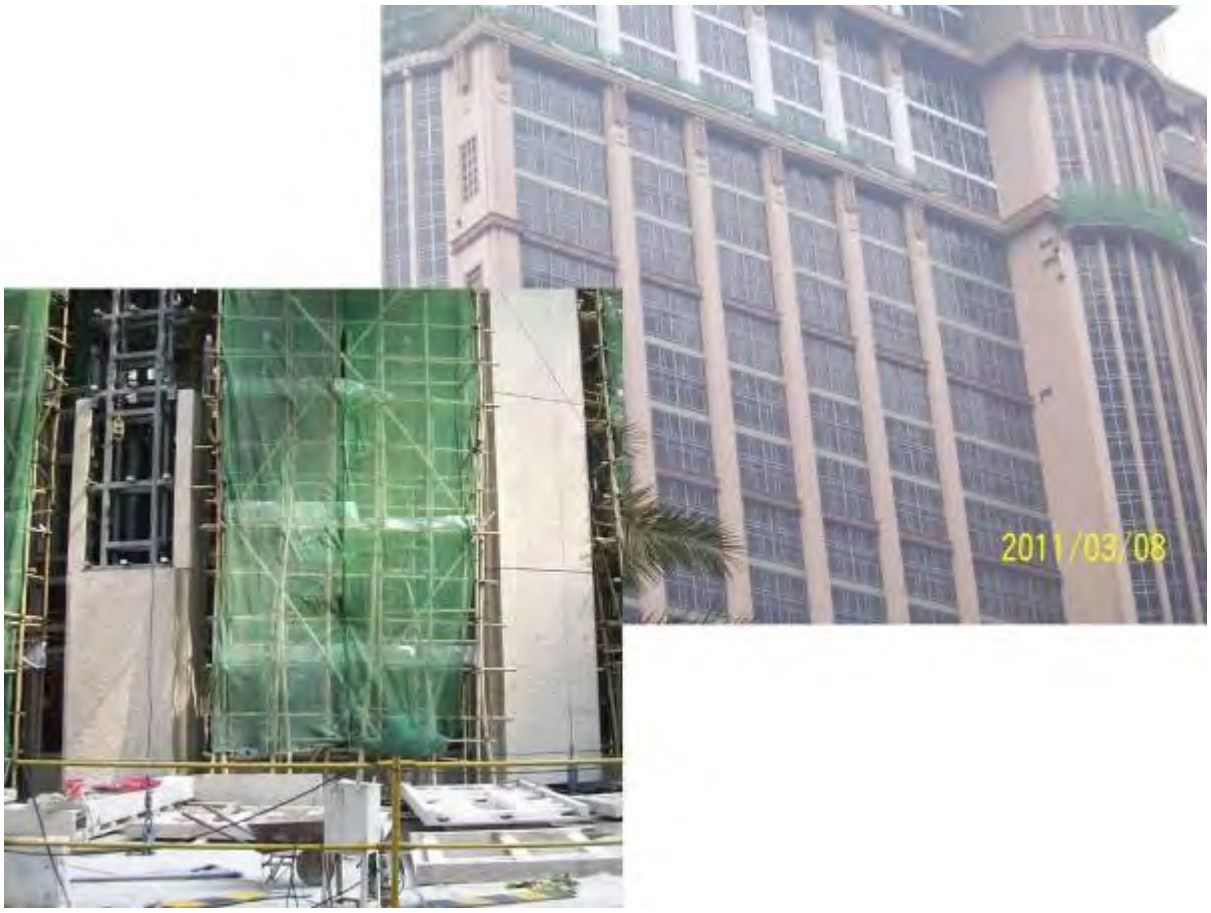

VENETIAN MACAU P1


VENETIAN MACAU P2


VENETIAN MACAU P2

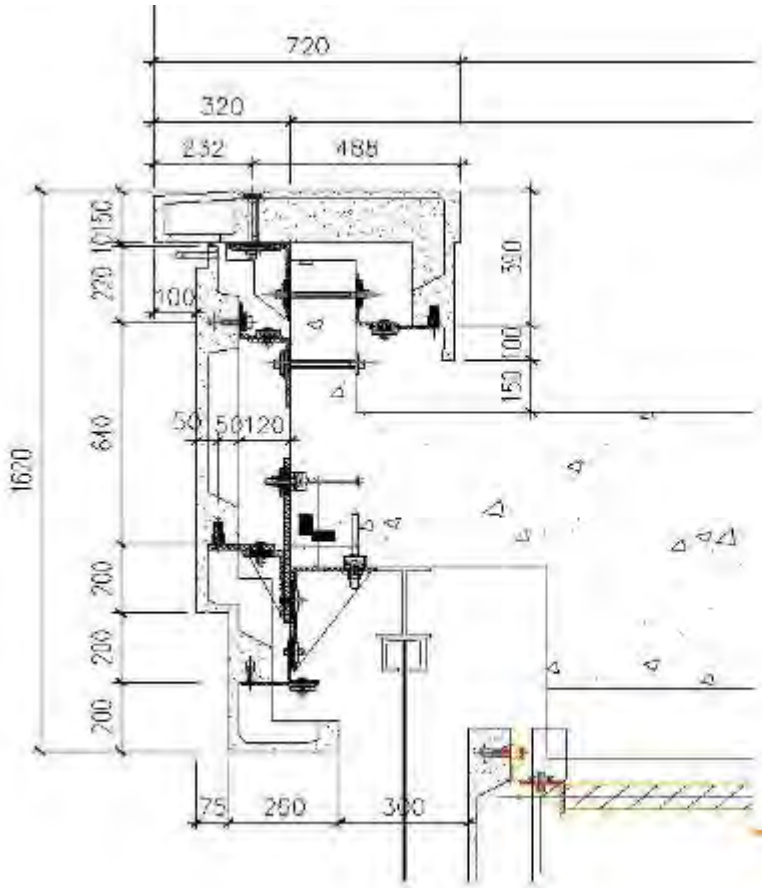

SHANGRI-LA
中山倍立达装饰工程材料有限公司
ZHONGSHAN BEILIDA DECORATIVE CONSTRUCTION MATERIALS CO.,LTD

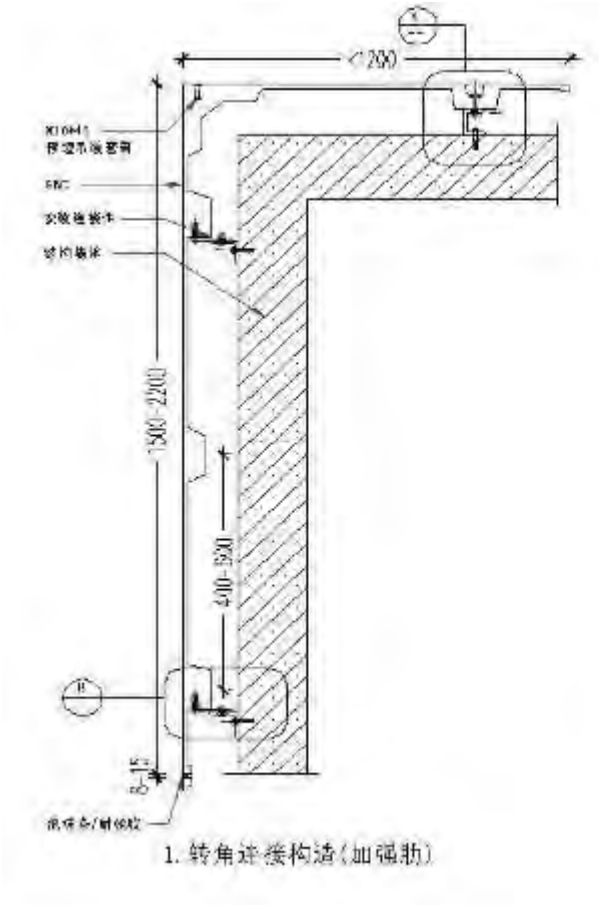

2011/03/08


2011/03/08

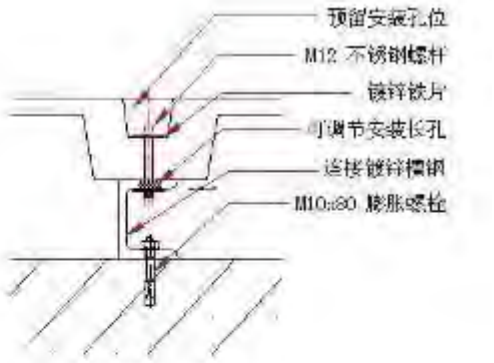
6.2Venetian Macau Design

Photos: AM-Photo 11~12

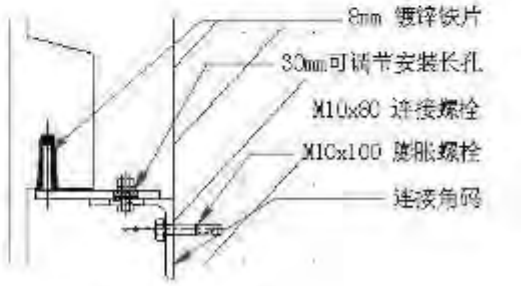

720
320
252
468
150
220
100
640
1620
200
200
200
350
100
150
50
50
120
75
250
300



1. 转角连接构造(加强肋)



A 连接大样图



B 连接大样图

CHAPTER VII
GRC Application of Replacement of Traditional Stone for Curtain Wall

7.1 Dalian Zoology Science and Technology Developing Zone Project Brief Introduction

1. Project Name：alian Zoology Science and Technology Developing Zone Project
2. Project Address：Dadong Gouzi viliage, Xin Zhaizi town, Gan Jingzi district,Dalian city.
3. Jobsite Condition： area J and area K, the total GRC is 47800 m^2, total work time is 180 days.
4. GRC curtain wall panels with colorful dried tangerine stone texture.
5. The curtain wall panels installation way is flexible suspending.
6. The area about 9m2/pc, the thickness is 15mm, the thickness of the ribs is 85mm,the weight for each panel is about 540kgs,the gap between two panels is about 15mm.

Photos: DL-Photo 1,DL-Photo 2

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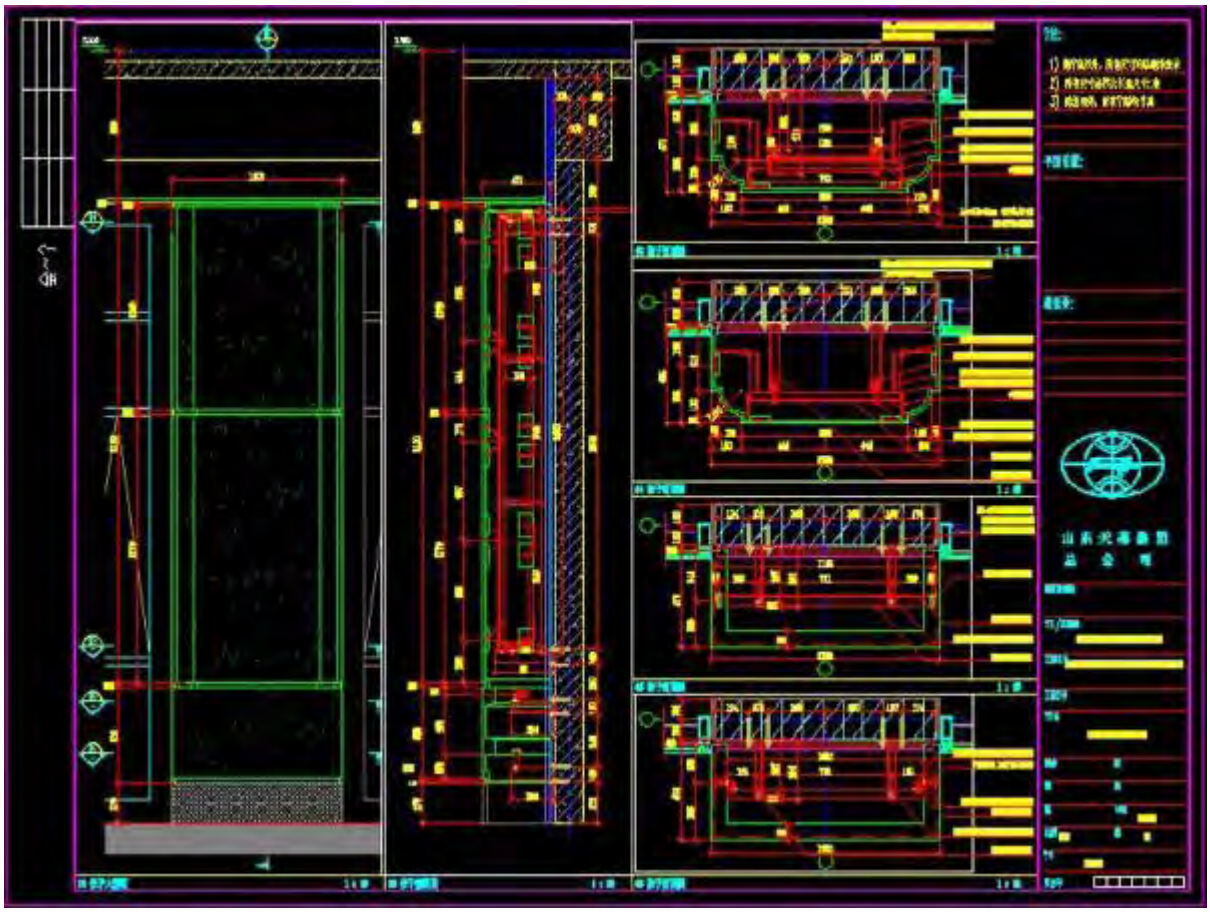
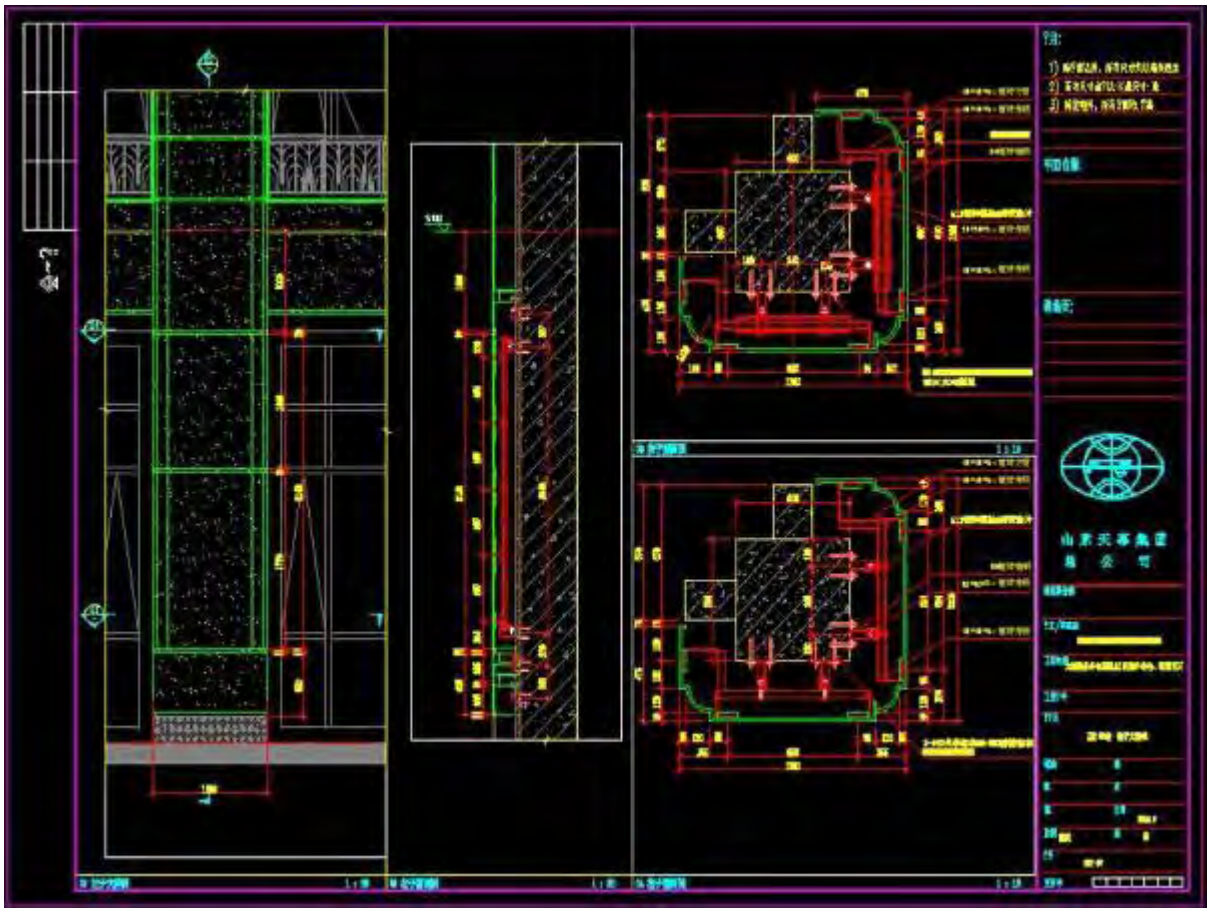
7.2 GRC Beam-column Panel Structure Design

Photos: DL-Photo 3,DL-Photo 4,DL-Photo 5





7.3 GRC Beam-column Panel Structure Installation

Photos: DL-Photo 6,DL-Photo 7,DL-Photo 8,DL-Photo 9,DL-Photo 10

7.4 GRC Finish

Photos: DL-Photo 11,DL-Photo 12