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## The Innovation of Glassfiber Reinforced Cement (GRC) Application in Buildings

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**Abstract.** One example of the innovation in building construction that is expansively used at present is Glassfiber Reinforced Cement (GRC). GRC is a cement product based on material mixed with fiberglass. GRC is one of the developments of concrete. This product easily and efficiently provides solutions to a variety of building designs. Additionally, its various forms can be applied to numerous types and functions of buildings. This research aimed to identify the suitability of GRC for several functions. The methods in this study employed a type of qualitative research, with data collection techniques in the form of observation and documentation in several examples of buildings that applied the GRC material innovation. Data analysis was obtained from observation related to GRC types, sizes, installation techniques, and functions in the building. Results showed that the GRC had various types, shapes, and sizes. It could be applied to the building exterior or interior. Each building used different GRC specifications tailored to meet needs and design of the building. GRC installation techniques could use the frame or without frames, adapted to the needs and types of GRC used.

Keywords: Glassfiber Reinforced Cement, Innovation, Application.

### 1. Introduction

Innovative ideas in the construction emerge due to a number of factors, in which the most dominant one is the desire to process materials into building materials that are robust, secure, accessible, inexpensive and eco-friendly. Such innovations, including the double skin façade also appear to minimize the use of energy in buildings (Dewi, Huang, & Murti, 2013). One of innovations currently used in building construction industry is Glass-fibre Reinforcement (GRC).

GRC is a product made of cement infused with fiberglass. GRC is one of the developments of concrete. This material is a composite material or mixture of concrete and glass. Its composition is comprised of sand, cement, acrylic polymer, water, aggregate, and alkali resistant fiberglass. This product is able to provide solutions to create various designs easily and efficiently.

Various types of buildings have different characteristics. GRC innovations applied in buildings have a wide selection of functions, types, shapes and sizes. Some studies revealed that the application of GRC could give a local impression in buildings (Hendriyani, Paramadhyaksa, & Salain, 2017) and the application of GRC in buildings was considered efficient and flexible with basic materials that could be integrated with other alternative materials (Munandar, 2018). In the previous research has explained that GRC could be installed as building structure (Branco, Ferreira, Brito, & Santos, 2001) and also proved that GRC is a green material which is strong, light, weather resistant, attractive and fire retardant (E.K.Vahidi, 2011). Based on this background, it is necessary to study the application of GRC materials in a number of building typologies to find out innovations in the application of GRC as architectural materials.

## 2. Methods

This research employed descriptive qualitative method by analysing aspects related to the object of research by presenting data in depth to the object of research (Prabowo & Heriyanto, 2013). The research investigated the application of GRC materials in a number of building typologies. The assessment was based on direct observations on the buildings that are already operating. The results were then interpreted to assess the effects of using GRC from various aspects, such as aesthetics, functions, materials, efficiencies, and installation installations.

## 3. Discussion

### 3.1. Application of GRC

#### 3.1.1. Wisma Anugerah Semarang

Wisma Anugerah is an office building consisting of six floors. On its exterior, GRC is applied as a secondary skin of building facades. GRC Cladding is applied to cover the entire outside of the building.



Figure 3.1. GRC Facade of Wisma Anugerah (authors, 2019)

The facade is composed of GRC panels that are 1m x 1m in size and have a thickness of 5 cm. GRC panels have holes with circular motifs, with different circle diameters on each panel. Aside from the aesthetic purpose, the GRC facade in this building also functions as sun shading. The circle holes on this facade serve as gaps so that sunlight can still enter the building.

GRC is applied at a distance of 1.5 meters from the outer wall of the building. The distance between the panel and the wall is quite wide due to cantilever in the building window. The installation of GRC was carried out by placing an iron frame on the first step on the wall of the building. Then, the GRC panel was arranged and attached to the iron frame by welding technique.

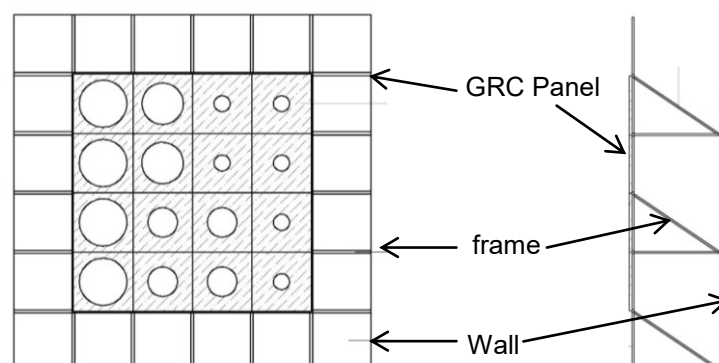


Figure 3.2. Illustration of GRC Installation (authors, 2019)



Figure 3.3. GRC Installed as Ceiling (authors, 2019)

GRC is also applied as a wall fence, which consists of two layers. The ordinary walls are inside whereas the GRC panels are outside. The walls support the GRC panels to stand firm. The distance between the GRC Panel and the wall is 0.5 meters. The iron frame used to connect the GRC panel has a thickness of +10 cm. In the interior, GRC is applied as a ceiling.

### 3.1.2. Citra Dream Hotel Semarang

Citradream Hotel Semarang consists of 9 floors. GRC in the Citradream Hotel building uses the GRC *krawangan* board with the *kawung* motif. GRC is applied as a secondary skin-building facade on the second floor in order to enhance to the building aesthetic.

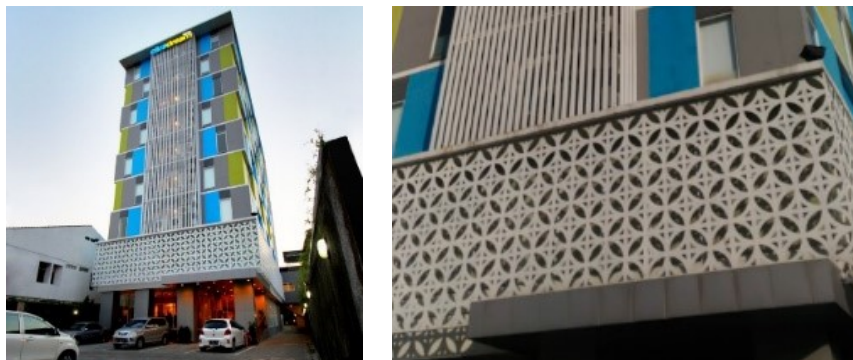


Figure 3.4. GRC Façade on Citra Dream Hotel (authors, 2019)

The GRC panel used has a thickness of 3 cm. This GRC *kerawangan* panel is applied at a distance of 0.5 meters from the building wall. To install this GRC, an iron frame was placed first on the wall of the building, and then the GRC panel was attached to the frame by being welded.

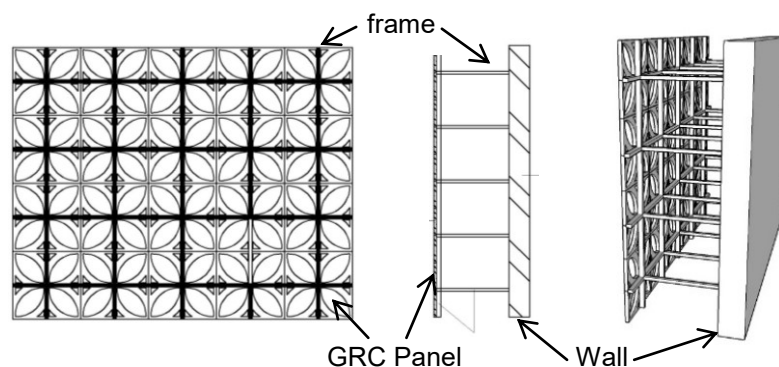


Figure 3.5. Illustration of GRC Frame and Installation on Citra Dream Hotel (authors, 2019)

### 3.1.3. Pesona Hotel Pekalongan

This building has six floors and a pawnshop in the hotel area. GRC is applied to the exterior as a wall of the hotel facade, which is a type of *kerawangan* (granular) GRC. GRC is applied as a secondary skin-building facade to function as building aesthetic and to cover the AC utility display on the walls of the building. GRC *kerawangan* used in the pawnshop has patterns and the same size as that applied to hotel buildings.



Figure 3.6. Pesona Hotel Pekalongan (authors, 2019)

The GRC facade was composed of GRC panel pieces that were previously printed. Two types of GRC panel shapes were then arranged to form geometric patterns. The GRC panel was circular in diameter 80 cm, with a thickness of 3 cm.

GRC panels were arranged on an iron frame that was installed on the wall of the building order to use hollow iron 2 cm x 4 cm. Installation of GRC on the frame was by means of welding.

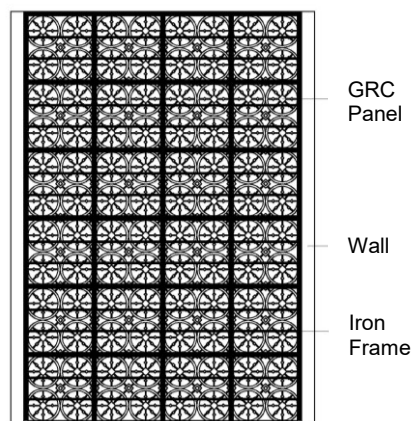


Figure 3.7. Illustration of GRC Frame and Installation in Pesona Hotel Pekalongan (authors, 2019)

### 3.1.4. Kota Baru Jambi Sport Building

Rehabilitation of Sports Building Kota Baru Jambi applies GRC material to the building exterior. A typical Jambi carved GRC ornament was applied around the building. GRC is applied as a secondary skin of building facades in order to renew the building appearance to look more magnificent, without doing enough demolition. In addition, the use of GRC secondary skin is to enhance the building aesthetic.



Figure 3.8. Kota Baru Jambi Sport Building (Hamidah, 2019)

GRC craftsmen produced the printed GRC materials directly at the project site by, to make it easy and cost-effective because there was no need for GRC panel shipping costs.

Installation was first carried out by placing the pipe frame, which was also used to frame the GRC panel. Then in the middle part of the frame was an iron wire with a diameter of 10 mm, for the attachment of the GRC panel. The printed GRC was then welded to the frame.

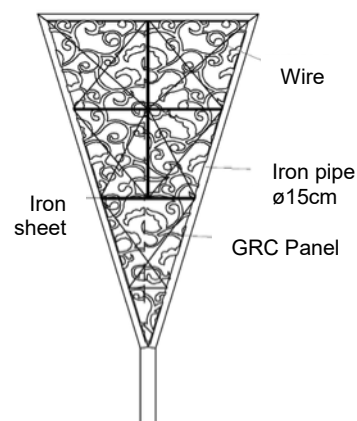


Figure 3.9. Illustration of Kota Baru Jambi Sport Building GRC Installation (authors, 2019)

### 3.1.5. Bank Indonesia Semarang

The Bank Indonesia Semarang building is the first building in the city of Semarang that applies the Glass Reinforced Cement (GRC) as the final completion of the building facade.



Figure 3.10. Bank Indonesia (authors, 2019)

Bank Indonesia Semarang buildings apply GRC as building facades, as well as other building components. GRC applied to the facade is a GRC Cladding in the form of a plain panel. The GRC panel size was 120 cm x 240 cm, 90 m x 240 cm, and other sizes that adjusted the shape of the building.

In addition, ornaments on the corners of the walls and other detailed components also consistently use GRC. The applied GRC is displayed as it is without other additional finishing, such as paint or other coatings.

To install GRC, the panel was attached to the building wall with the frame. The GRC panel was installed using screws so that the GRC panel attached perfectly to the walls of the building. The applied GRC is displayed as it is without other additional finishing, such as paint or other coatings.

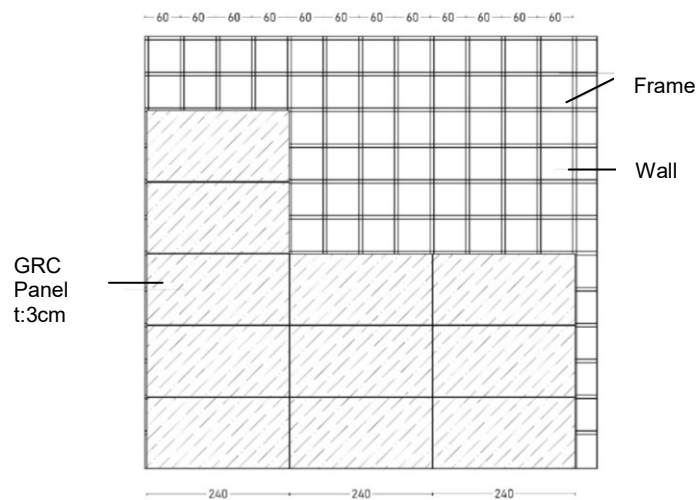


Figure 3.11. Bank Indonesia GRC Installation (authors, 2019)

### 3.1.6. Restaurant at Paltrow City Semarang

The KFC Paltrow City building consists of two floors and one basement. The GRC application on the exterior of the KFC building is located in part of the facade of the building on the second floor, which uses GRC *kerawangan* with geometric motifs.

In addition to aesthetics, this GRC *kerawangan* facade can also function as sun shading. The GRC panel was cut into several modules with the size of each module 80cm x 80cm, and approximately 1.5 cm.



Figure 3.12. KFC Paltrow City's GRC Facade (authors, 2019)

The installation of GRC used a hollow iron frame of 3 cm x 1 cm. The iron frame that was first installed on the part of the building would be applied to GRC. Then the GRC panel was affixed to the iron frame using electric welding. Once installed, the panel was given finishing wall paint.

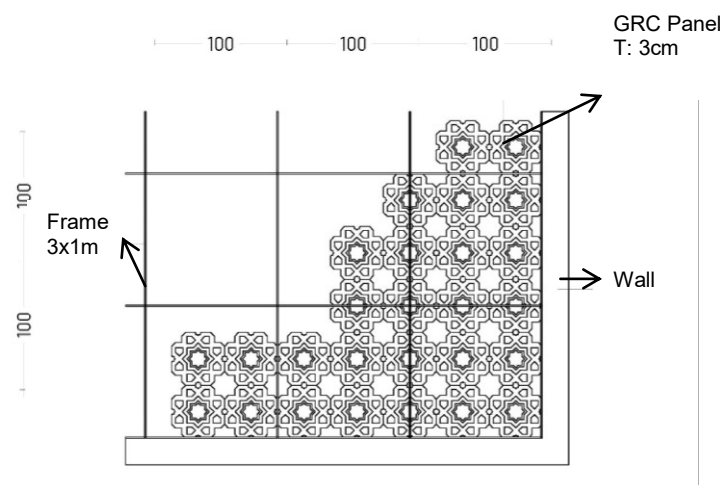


Figure 3.13. Illustration of KFC Paltrow City's GRC Installation (authors, 2019)

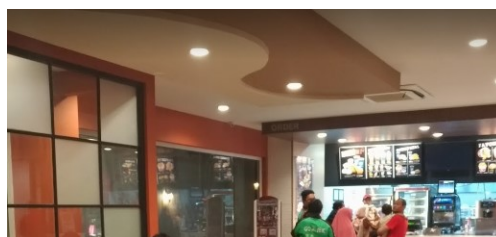


Figure 3.14. GRC applied on ceiling (authors, 2019)

The GRC application on the interior of the building is applied as a ceiling of the room. The shape of the ceiling consists of a flat ceiling with a variety of suspended ceilings. The installation of GRC ceiling used elbow frame. The frame was installed first on the ceiling of the room, as the GRC panel attached. After the frame was installed, the GRC panel was placed using screws. Hanging ceiling has a thickness of about 15 cm from a flat ceiling.

### 3.1.7. At- Taufiq Mosque, Semarang

At-Taufiq Mosque Building has two floors. The GRC application at the At-Taufiq mosque is located on its dome and tower. The mosque dome uses the GRC panel that has been printed according to the shape and size that fits the design. The GRC panel was printed with certain modules, which were then compiled during the dome installation.

The installation of GRC dome used iron pipe construction. The iron pipe as a frame was installed first on the mosque building. After the iron frame was installed, the GRC panel was arranged above the frame. Electric welding then joined GRC and the frame. Once installed, the GRC dome was re-poframed with a specimen mixture to prevent leaks. On the outside, GRC was given finishing paint to enhance the appearance of the dome. Meanwhile on the inside, the GRC panel and iron pipe frame were exposed to interior ornaments.



Figure 3.15. Dome Interior (authors, 2019)



Figure 3.16. Cladding of GRC Tower (authors, 2019)

In mosque towers, GRC material is applied as a cladding to the outer walls of the tower. The GRC cladding panel size adjusts the shape of the tower side, which is about 50cm x 160cm. It is given a light gray paint finish, to make it look neat.

### 3.1.8. Al Mujahidin Mosque, Semarang

The mosque building consists of two floors. This mosque applies GRC *kerawangan* material to its exterior walls. GRC panel has geometric Islamic motifs. The panel has a width of 120 cm and a height of 160 cm, and a panel thickness of about 3 cm. GRC *kerawangan* in this mosque serves as ventilation and natural lighting of the room.





Figure 3.17. Al Mujahidin Mosque (authors, 2019)

GRC *krawangan* panels were installed by placing the GRC panel on the wall of the building. GRC panels were installed rather protruding into the wall so rainwater would not fill the building. Then the GRC panel was glued to the wall by being welded. Once installed, GRC *kerawangan* was poframehed again to clean up weld marks and impact marks. Once installed perfectly, then GRC *krawangan* was given finishing wall paint.



Figure 3.18. GRC ornament (authors, 2019)

### 3.1.9. Baitul Makmur Mosque, Pekalongan

This mosque consists of two floors. GRC is applied to the mosque's dome and ornament. The GRC panel, which is applied as a dome, is composed of panel modules that have been printed with adjustable shapes and sizes.



Figure 3.19. Baitul Makmur Mosque (authors, 2019)

The iron pipe frame was used as a dome construction. The dome used two layers of GRC panels. First, the iron frame was installed on the building. Then the inner GRC panel was installed by being welded in the frame. Once installed, then GRC was poframehed to prevent leaks. The next step was to install the outer GRC panel. The installation technique was the same as the inner layer GRC.



Figure 3.20. GRC Framework and Panel (authors, 2019)

The Baitul Makmur Mosque also applies GRC material for mosque ornaments. GRC *kerawangan* is applied to the pulpit and several other parts. The mosque uses GRC Islamic geometric motif ornament.

#### 3.1.10. The Residence of Bukit Anggur, Semarang

The house that is located at Jl. Bukit Anggur No. 18, Bukit Sari, Semarang, applies GRC as a building facade. It uses GRC *kerawangan* with *parang* batik motifs with the combination of leaf and floral motifs that serve as aesthetics and sun shading. GRC panel has a thickness of about 3 cm. GRC is given a light gray wall paint finish.



Figure 3.21. GRC *Krawangan* Pattern (authors, 2019)

The GRC *krawangan* panels were installed by placing the GRC panel on the building wall. Then the GRC panel was glued to the wall by being welded. Once installed, GRC *kerawangan* was poframehed again to clean up weld and impact marks. Once installed perfectly, then GRC *krawangan* was given wall paint finish.

## 3.2. Analysis

### 3.2.1. Types of Buildings Using GRC

GRC material can be applied to various types of buildings, with various heights. It can be seen on the table 1:

Table 3.1. GRC Applications in Several Building Typologies

No	Building's Name	Building Type	Number of Floor
1	Wisma Anugerah, Semarang	Office	6 floors
2	Citradream Hotel, Semarang	Hotel	9 floors
3	Pesona Hotel, Pekalongan	Hotel	6 floors
4	Kota Baru Sport Building	Sport Building	2 floors
5	Bank Indonesia, Semarang	Office	10 floors
6	KFC Restaurant Paltrow Semarang	Restaurant	2 floors
7	At Taufiq Mosque, Semarang	Religious Building	2 floors
8	Al Mujahidin Mosque, Semarang	Religious Building	2 floors
9	Baitul Makmur Mosque, Pekalongan	Religious Building	2 floors
10	House at Bukit Anggur, Semarang	House	2 floors

Source: Authors, 2019

GRC can be applied to the exterior of the buildings, as their facade and fence that function as construction and beautify the appearance of the building. GRC can also function as sun shading. In addition, the GRC material can be applied to the interior of the buildings, as it is used as a ceiling and ornament on the interior walls, because it is lightweight and easily shaped.

Table 3.2. GRC Functions

No	Building's Name	GRC Application	Function
1	Wisma Anugerah, Semarang	Exterior: Secondary skin Interior: Ceiling	Sun shading, aesthetic
2	Citradream Hotel, Semarang	Exterior: Secondary skin	Aesthetic
3	Pesona Hotel, Pekalongan	Exterior: Secondary skin	Aesthetic, covering utility equipment
4	Kota Baru Sport Building	Exterior: Secondary skin	Aesthetic
5	Bank Indonesia, Semarang	Exterior: Facade Cladding and ornament	Façade finishing, aesthetic
6	KFC Restaurant Paltrow Semarang	Exterior: Facade Cladding Interior: Ceiling	Aesthetic, sun shading
7	At Taufiq Mosque, Semarang	Exterior: minaret Cladding, Dome Interior: Ceiling	Aesthetic, construction
8	Al Mujahidin Mosque, Semarang	Exterior: Facade ornament	aesthetic
9	Baitul Makmur Mosque, Pekalongan	Exterior: Façade ornament, minaret Cladding, Dome Interior: Ceiling, <i>mihrab</i> ornament	Aesthetic, construction
10	House at Bukit Anggur, Semarang	Exterior: Façade Cladding	Aesthetic, sun shading

Source: Authors, 2019

### 3.2.2. Specifications in Buildings

Various types of GRC can be applied throughout the buildings, adjusting to their functions and needs. Besides that, the sizes of the GRC can vary, adjusting to the building shapes. However, if the GRC is used in a large enough area, then the panel must be made into

several smaller size modules. This is to facilitate the mobilization of the GRC panel from the production site to the project location, and to facilitate installation. The thickness of the GRC panel also varies, ranging from 3 cm to 10 cm, and it does not rule out the possibility of other thickness, based on building functions and needs. The specifications of GRC can be seen on the table 3.

### 3.2.3. Setting Up GRC

Based on the discussion, the GRC Setting could use two different ways, as follow:

#### - Using Iron Frame

The iron frame is used to apply GRC that has a wide enough size, usually applied as a secondary skin, dome, ceiling, and so on. The frame can function as construction, stiffener, as well as the place where the GRC panel attaches. The order usually uses hollow iron, iron wire, iron pipe, or elbow frame. Frame size adjusts to building needs.

To install GRC, firstly the frame was placed in the building. After that, the GRC panel was arranged and put together on the frame, by being welded. Next, the GRC was again poframehed using specimen dough, to neatly arrange and soften its surface, which has weld marks and *colframeions* during installation. If GRC is installed perfectly, finishing is carried out to enhance the building appearance.

#### - Without iron frame

This technique can be used on GRC that is applied directly to the fields such, as walls and ornaments of GRC. Installation of GRC cladding and ornaments can be applied by attaching the GRC panel directly to the wall. Adhesives used specimen dough and were reinforced with screws, so the panels attached perfectly to the wall. Next, refinishing was carried out to remove screw marks and smooth the surface of the GRC. After that, finishing could be carried out using paint or coating, or without paint finishing. Welding techniques were used during the installation. In this case, welding joined the GRC module and the frame.

Table 3.3. GRC Specifications and Installations

No	Building's Name	GRC Type	Panel Dimension	Installation
1	Wisma Anugerah, Semarang	GRC Cladding, GRC Ceiling	Module: 1 x 1m, thickness: 2, 5, 10 cm	Using iron frame
2	Citradream Hotel, Semarang	<i>Krawangan</i> GRC	Module: 1 x 1m, thickness: 2 cm	Using iron frame
3	Pesona Hotel, Pekalongan	<i>Krawangan</i> GRC	Module: d= 80cm, thickness: 3 cm	Using iron frame
4	Kota Baru Sport Building	<i>Krawangan</i> GRC	Module based on pattern, thickness: 2cm	Using iron frame
5	Bank Indonesia, Semarang	GRC Cladding, GRC Ornament	Module: 240x90cm, 240x120cm, thickness: 2-3 cm	Not Using iron frame, the panel is attached on the wall
6	KFC Restaurant Paltrow Semarang	<i>Krawangan</i> GRC, GRC Ceiling	Module: 80x80cm, thickness: 1,5 cm	Using iron frame
7	At Taufiq Mosque, Semarang	GRC Cladding, Dome GRC	Module: 160x50cm, based on the shape of dome, thickness: 2-5 cm	Using iron frame and also not Using iron frame, the panel is attached on the wall
8	Al Mujahidin Mosque, Semarang	GRC <i>Krawangan</i> , GRC Ornament	Module based on the shape, thickness: 3 cm	Not Using iron frame, the panel is attached on the wall
9	Baitul Makmur Mosque, Pekalongan	Dome GRC, GRC <i>Krawangan</i>	Module based on the shape, thickness: 3-5 cm	Using iron frame and also not Using iron frame, the panel is attached on the wall
10	House at Bukit Anggur, Semarang	<i>Krawangan</i> GRC	Module based on the pattern, thickness: 3cm	Not Using iron frame, the panel is attached on the wall

Source: Authors, 2019

#### 4. Conclusion

Glassfiber Reinforced Cement (GRC) material can be applied to all types of buildings, both in their exterior and interior.

In general, GRC in the exterior of the building is applied as building facades, roof coverings, building fences and ornaments. Meanwhile, GRC in the interior of the building is applied as ceilings and interior ornaments. The GRC application in buildings can function as an aesthetic element, construction, cladding, and shading.

GRC applied to buildings has different shapes and sizes based on the functions and needs of the GRC in the building. Panel size used generally has a thickness of 1 cm to 10 cm, but it does not rule out the possibility of using GRC material with a thicker or thinner size. The width of the GRC panel can also be adjusted to the design. For buildings that apply expansive GRC materials, the GRC panel is divided into several smaller size modules, to facilitate the mobilization and installation process.

The GRC installation system in buildings can be carried out by using iron frames or without frames. It adjusts the type and size of the GRC used. GRC gluing technique uses electric welding with specific dough and screws.

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