13 GRC IN NORTH AMERICA

H. J. MOLLOY
Molloy and Associates, Hutchins, Texas, USA

SUMMARY: A discussion of the history of GRC in the United States of America would not be possible without the development of steel stud framing for architectural concrete panels. It was this development in the 1970s by Mr. Iver Johnson (of the USA) that propelled the use of GRC for panels and generated the required volume of alkali-resistant glass to persuade the glass manufacturers to continue production of the glass.

Contributions by other engineers helped in the development and application of the new framing concept. Support in the United States from both glass manufacturer Owens Corning Fiberglas and the Precast/Prestressed Concrete Institute was instrumental in the positive growth of the glass fiber reinforced concrete concept provided by the steel frame design.

The use of glass fiber for the reinforcement of other concrete products was the direct benefit of the growing popularity of the fiber concrete architectural panels. As a result of this increase in the confidence of the fiber concrete matrix, it began to be used in precast products as an asbestos replacement, and as the technology became known it became popular in most countries in the world.

The credibility of the concept of alkali-resistant fiber reinforced concrete owes its success in great measure to Mr. Johnson and the many individuals and companies who have contributed to the design, development and production of fiber reinforced concrete products.

In the text of this paper some of the problems and solutions encountered will be presented, as well as contributions from specific individuals and companies.
KEYWORDS: Alkali-resistant glass, asbestos replacement, fiber concrete, glass fiber, precast, steel frame.

THE STEEL STUD SYSTEM: A BRIEF HISTORY

The growth in use of the material called glassfiber reinforced concrete (GFRC) in my opinion would never have happened so rapidly had it not been for the introduction of the steel stud frame to support the GFRC cladding.

Many of us have heard the story of how alkali-resistant (AR) glass originated in Europe and North America, but how the steel stud frame was developed and introduced has not been reported. A brief history will set the stage.

When the glass producers developed AR glass and began to survey the construction industry to identify opportunities, their objective was to identify and develop a market for the glass that would equal or surpass the volume used to reinforce plastic resin systems.

The first market, which was targeted in the late 1970s, was the exterior cladding market dominated at the time by precast concrete. The laboratory group, of which I was a member, was assigned the task of developing a system using AR glass to penetrate the market. None of us had any experience in that market, nor did we know much about concrete, nor did we know what the GFRC would do when sprayed in large sections. All of the tests we had performed were under laboratory conditions, far different from actual plant production, and industrial applications were far different from our experiences in the laboratory environment. We had a great deal to learn and we needed to find companies to work with.

At this time I met with Sid Freedman of the Prestressed/Precast Concrete Institute. My objective was to convince him to sponsor a committee solely devoted to fiber concrete. It was to be a method of collecting, publishing data and exchanging ideas, supplied by the two glass producers and members of companies interested in the fiber concrete concept. He agreed and the PCI/GFRC committee was formed. The first Chairman was Dick Welch, President of Concrete Technologies, a company in the precast concrete cladding business.

At the time the English glass producer, Cem-FIL, called the product GRC (glass reinforced cement), and we in America with Owens Corning Fiberglas called it FRC (fiber reinforced concrete). I felt that the word ‘concrete’ was more substantial. Ralph Sonneborn, then President of Cem-FIL USA, and I compromised and named the new product GFRC.

My association with PCI allowed me to contact many of the precast concrete producing members of PCI to expose them to the new GFRC system of producing cladding panels. Later we would invite interested members to a school at the laboratory to train production personnel in the then-known methods of producing GFRC.

The first company to indicate an interest in GFRC was Glascon owned by Iver Johnson. The second was Concrete Technologies managed by Dick Welch. Within the same time period in the late 1970s, Concrete Technologies produced GFRC panels for a small project in Ohio (see Figure 1).

Figure 1 - Fascia panels by Concrete Technologies

There were many advantages to the new system of which we are all now aware and which we promoted. There were disadvantages also: the main one was warping. The small panel allowed us to control this at erection.

However, as the demand for larger panels by the producers increased, the necessity for stiffening ribs to reduce warping became apparent. Several methods were tried. GFRC over foam, GFRC over cardboard shaped ribs, and stand up ribs were all tried (see Figures 2 and 3).

Figure 2 - Early rib design

Figure 3 - Early rib design (foam core)

All had significant problems. The large rib sections restrained the GFRC skin from moving due to expansion and shrinkage and this eventually resulted in cracking. In addition, the rib shape actually telegraphed its image through the face and was visible when the panel was wet, and as the panel was coated with pollutants.

Figure 4 - Early ribbed panel

During this time Iver Johnson of Glascon had agreed a small project to produce GFRC closet modules for a chain of motels to be built in the Minneapolis area. We discussed the problems with foamed ribs. The next day he invited me to examine a new idea he had to stiffen the flat plate area of the closet. He had used two-inch by four-inch wood studs and built a frame that was then anchored to the closet with large nails through the stud at two-foot intervals. Each nail was then covered with GFRC and bonded to the closet skin. This is illustrated in Figure 5.

Figure 5 - The first stud frame using wood

The frame did everything needed. It provided a method of stiffening the flat plate area with a minimal amount of restraint; it provided a method of attaching the closet to the building; it provided a cavity to accept insulation; and finally it provided a surface to accept the drywall board. What a fantastic idea!

Figure 6 - Closet module installation

Two motels were built using this method of using GFRC and are still in use. The closet installation is shown in Figure 6. Note that the module projects from the building, increasing useable floor space.

A few weeks later while discussing the project Mr Johnson advised me that he had booked another project to use GFRC. The panels were to be three storeys tall. I advised against it due to the size, and in particular the unknowns of using GFRC in such a large section. He was not deterred and advised me he was using trusses at the edge of the window sections and at the edge of the panel. After erection these trusses were to be cut at the floor level to allow for panel movement. This is illustrated in Figures 7 and 8.

Figure 7 - First project with steel stud

Figure 8 - First project completed

These pictures illustrate the installation and finished building. To date the few cracks noted are at the window corner.
A few months later while I was in his office Mr Johnson was speaking to a steel stud supplier regarding an office building he was renovating. He asked the supplier to bring over a few steel studs for him to examine.

In his mind the problem with large GFRC skins was solved and in fact it was. His next project used the painted steel studs as illustrated in Figures 9 and 10.

Figure 9 - The first large steel stud project

Figure 10 - Positioning (above) and stripping (right)

During this development we at the laboratory were much involved as advisors only. The stresses generated in the GFRC skin were recorded from test panels and suggestions for the design of the steel stud frame were made. These included having all anchors facing the centerline of the panel to minimize shrinkage stresses. Additionally the anchor was to be welded only at the top (see Figure 11) to allow movement by the GFRC skin while expanding or shrinking. The bonding pad was to cover only the horizontal leg illustrated in Figure 12, to allow it to move within the pad if necessary.

Figure 11 - The 'L' anchor

Figure 12 - Anchor and bonding pad

The studs were not to touch the GFRC skin to eliminate image telegraphing. Note these features in Figures 11 and 12.

Figure 13 - Stud type review

The excitement generated by this new idea was contagious. It also exposed some problems. Expansion and contraction became a major factor and the fact that GFRC was a non-structural façade was of major importance.

Figure 13 illustrates the old way and the new, and Figures 14 and 15 show the new steel stud system being used to provide insulation cavities, provide a structural support for window assemblies and a method for attaching interior finishing.

Figure 14 - Bay window structures

Figures 15–19 illustrate the trend after introducing the new stud system, more complex and larger and heavier panel skins.

Figure 15 - Heavier and more complex panels

Figure 16 - Heavier frames now galvanized

Figure 17 - Larger and more complex designs

The structural engineers who were intimately involved in the development of the more sophisticated steel stud frame were Ray McCann, Vic Roblez and Ed Knowles. These gentlemen, members of the PCI/GFRC Committee, performed the calculations and developed the design procedure used for the stud system.

Figure 18 - Larger panels with 6-inch studs and box ribs

Figure 19 - More complex and heavy

They also addressed the problem of weight and the deflection on the anchors.

The industry wanted larger panels that were heavier. The method of welding the anchor at the top allowed the anchor to deflect due to the weight. This had to be corrected and it was. Additionally a large market for these panels was in seismic zones and required a special anchor. Figures 20–25 illustrate the anchor designs.

Figure 20 - Flat plate tee gravity anchor

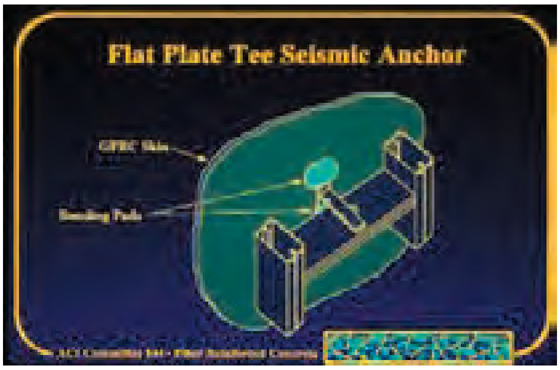

Figure 21 - Flat plate tee seismic anchor

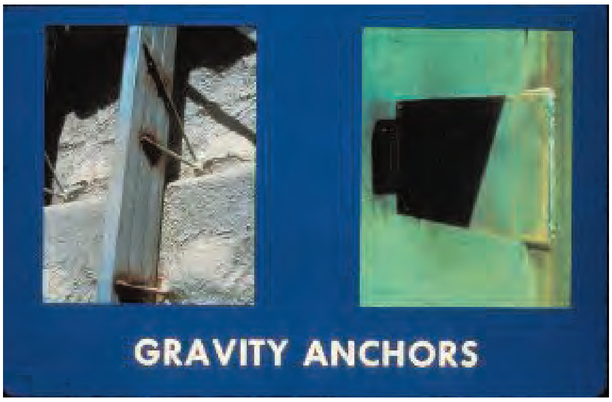

Figure 22 - Truss and bar gravity anchors


Figure 23 - Truss anchors with galvanized 6-inch studs


Figure 24 - Bar gravity anchor


Figure 25 - Galvanized steel studs and stainless steel anchors

As a result of these contributions, larger panels were designed and produced. Galvanized studs were now used to satisfy building codes (see Figure 25).

Figure 26 illustrates one section of an arch and Figure 27 shows the assembly. Figure 28 illustrates the building installation. Figure 29 illustrates one elevation of the finished building.

Figure 26 - Ramada Inn panel one half arch

Figure 27 - Full arch

Figure 28 - Arch installation

Figure 29 - Ramada Inn Hotel San Francisco

Larger projects were designed such as that illustrated in Figure 30, the Marriot Hotel in San Francisco.

Figure 30 - Marriott Hotel San Francisco

The steel frame and GFRC has provided the architect with a method of producing unique shapes, which can be used to solve problems. For example, the design of a Mormon Temple required a tower on the building; however, the weight of the precast concrete was such that it exceeded the structural capability of the building. GFRC with a steel stud frame was used. Figure 31 illustrates the size of one component and Figure 32 shows the near completed structure.

Figure 31 - Lower flute illustrated for size

Figure 32 - Illustrating the building size

There are many examples of how the steel stud frame and GFRC has provided the architectural community with a unique product with unique features.

None of this would have been possible without the gift of the steel stud frame concept to the industry from Iver Johnson of Minneapolis, Minnesota.

Thank You, Iver Johnson.