There seems to be a slight degree of confusion in the marketplace as to what is this product called GRG—glass fiber reinforced gypsum. This article will deal with very specific technical issues concerning GRG—the material, not finished products. It is my contention that not enough is known about the basic GRG composite and its physical properties. Otherwise there would not be all these debates in the marketplace and architect’s offices about whose product is better.

The other issue that I see is that in what I call the “construction equation” for GRG, there are no engineers or trained materials people to properly evaluate the manufacturers’ product claims. A designer develops shapes and profiles for the project. An architect agrees and includes GRG in his specification that is, many times, a combination of several manufacturers’ specification. This results in a document that is impossible to bid accurately and impossible to properly adhere to if successful. This goes out to bid via the general contractor and drywall contractor to the GRG manufacturers who submit a bid. Normally the low-cost bidder gets the project and submits some shop drawings geared to supplying pieces that fit. In these steps when has a qualified engineer looked at any test results covering the physical properties of the particular product submitted or looked at those results in the context of the specific use and attachment of the product?

It is my opinion that in most cases, GRG is either over-engineered or under-engineered for its use. (I use the word engineered loosely because no engineer has looked at it.) I get these answers from certain producers: “It came out of the mold and made it to the job site, that’s good enough” and “Besides, no one has ever gotten killed by a falling piece.” There is a certain amount of validity to these statements, but I believe that with a little knowledge and understanding about the material, its usage could expand because proper designs and engineering of pieces would make it more economical to use.

To this end, a small group of producers are working with the ASTM C-11 Committee to develop several specifications to cover GRG. As it stands now we see three ASTM specifications being developed. They are, in order of priority, (1) a specification on GRG, the material, (2) a specification of GRG finished products and (3) a specification on the installment of GRG.

It is the first of these specifications I want to cover in this article since it will serve as the foundation for the others.

Proposed ASTM Specification for GRG (the material)

The proposed “Standard Specification for Glass Fiber Reinforced Gypsum” is working its way through ASTM C-11 Committee, and Draft #5 has been circulated for review before the next committee meeting that will be held in Tucson, AZ this month. The critical section of this specification pertains to the material’s physical properties and the tests used to obtain these results. I will review each of the important physical properties, the tests used and why the results are important to the designer and purchaser of GRG.

Flexural Strength

Of all the properties in the specification, I believe the results obtained from running ASTM C 947 (Dry) are the most telling in terms of the quality of the GRG and how it will perform. It can also be used as a very effective quality control test from the purchaser’s perspective to make sure the product supplied meets the design specifications. In addition it supplies the values to enable a designer or engineer to calculate appropriate piece sizes, shape and attachments for specific conditions. (See Figure 2)

Glass fiber reinforced gypsum is

GRG — Cont’d on page 26
a composite material. By definition a composite is composed of a matrix material and a reinforcement material. The matrix has certain properties that are enhanced by the addition of a reinforcing fiber. The characteristics of the reinforcing fiber and the amount of the fiber play an important part in the physical properties of the composite.

Figure 1 is a representative example of the stress/strain curve generated when a composite is tested under load. The straight line region marked as A to B is the range where the composite is able to carry the applied load. At point B the load has exceeded the capability of the matrix to carry the load and the matrix has cracked. This value is called the Limit of Proportionality (LOP) or Flexural Yield.

In the region B to C the load has been transferred to the glass fiber reinforcement where the load is being carried by an action known as fiber pullout until the load can no longer be carried, point D, which is known as Modulus of Rupture (MOR) or Flexural Ultimate. The slope of line between B and C also indicates the critical fiber percentage. If the line is horizontal, the fiber is at the critical reinforcement percentage. If the line is negative, the fiber percentage is below the critical amount required; conversely if it is positive, the fiber percentage exceeds the critical amount required. Ideally, the slope of the line should be slightly positive.
The Strain capacity of the composite, which is an indication of its ductility or toughness, can be seen, as well as calculated from the region between the LOP and the MOR values. The greater the distance between the LOP and the MOR points, the more ductile the material.

Designers and engineers can take these values and plug them into design calculations to determine size, shape, attachment points and type of attachments for any piece made from GRG.

Additionally, these values give important information about the specific GRG in question, how it was made, how well it was made and the amount and type of glass fiber used. This test is very inexpensive and easy to run so that it can be used as a quality control test or for spot checking by inspecting architects.

It is also important for the purchaser to understand the matrix strength of the GRG material. No matter what the various suppliers claim the MOR values to be (claims of 3,500 to 10,000 psi are in the literature), the gypsum matrix in GRG will crack between 1,500 and 2,000 psi. The MOR value indicates the ultimate flexural strength of the specific composite tested. This is a direct function of the type and amount of glass fiber used in the composite, as well as an indication of manufacturing quality. The spray chop method and the hand lay-up method both give isotropic reinforcement properties to the composite. The reason that the MOR values vary from manufacturer to manufacturer and between the two production processes has to do with glass fiber content, the fiber diameter and fiber length used. The wet out of the fiber by the matrix during production will also influence the MOR.

Impact Resistance

The impact resistance of GRG is an important “in use” physical property. A large percentage of the GRG produced in the North American market is used in column covers in high traffic areas such as shopping centers and hotel lobbies. The ability to withstand the people hazards is very critical to a successful installation. The specification calls for ASTM D 257-87 (Izod-un-notched method) as the test to be used. Acceptable values for GRG would exceed 3 ft-lb/in.

More work needs to be done in this area to characterize the flexural strengths of the various gyspums used and the various types of glass fiber reinforcements. Otherwise the controversy will continue to rage.

Hardness

There are two tests that can be used to measure the surface hardness of GRG. ASTM D 2583 (Barcol) or D 785 (Rockwell) are acceptable. A typical Barcol value is 85, while a typical Rockwell value is 70. The hardness value gives an indication of scratch resistance of the GRG which is, in turn, an indication of in-service behavior.

The committee members view the specification as a great step forward to legitimize and standardize the GRG industry.

Coefficient of Thermal Expansion

The thermal expansion values are important to know when GRG parts are to be designed and installed. If allowances are not made for thermal movements in installation, stresses can be induced in the pieces that will either cause the piece to crack or the joint to fail. In either event there is an unhappy customer. ASTM D 696 is used to measure the value. The Thermal Expansion Coefficient of GRG should not exceed 5.8 x 10^-6 in./in./F°.
Humidified Deflection

The humidified deflection test gives an indication of the behavior of the material in an in-service situation. The results of this test will correlate to the quality of the composite and the amount of glass fiber reinforcement used. It will also influence the attachment method and frequency of attachments. Tested according to ASTM C 473, GRG should not deflect greater than 1/8 inch.

Compressive Strength

In the context of composite materials, compressive strength values can be misleading. A composite material utilizes its flexural strength, not its compressive strength. However, since we are dealing with the construction industry, everyone is comfortable with knowing what the compressive strength is even though the product is never used in compression. GRG has a compressive strength that exceeds 8,000 psi when tested according to ASTM C 109.

Surface Burning Characteristics

Since GRG is used in interior applications and typically in high people traffic areas such as hotel/casino lobbies, shopping malls, retail stores and in accordance with ASTM E 84, GRG has a flame spread index of 0 and a smoke developed index of 0.

Density

The dry density of GRG is another indicator of quality production. The typical dry density is between 100 and 105 lb/ft³. If it is any lighter there is too much air in the composite as the result of over-mixing or poor compaction. If it is heavier, the producer should check his raw materials. Density is also a good indicator of mix yields and could give an indication of part weights. Density is measured according to ASTM C 472.

Nail Pull out

Since the majority of GRG parts are either screw or nail attached it is important to know the pull out resistance of the material. This is another value that can be used by an engineer to calculate a safe, but economical attachment design and frequency. ASTM C 73 is used to determine the nail pull resistance, which should exceed 200 lb-ft.

Summary

The foregoing has been a review of the proposed “Standard Specification For Glass Fiber Reinforced Gypsum” currently working its way through ASTM C-11. The committee members view the specification as a great step forward to legitimize and standardize the GRG industry. By accomplishing this, the industry will continue to grow by the engineering of new and proper uses for GRG.

About the Author:

Hiram Ball, Jr., started his business career with the Fiber Glass Div. of PPG industries, rising to Manager of Market Development. In 1980 he became Director of Forton PGFRC, Inc. where he developed the market for polymer modified glass fiber reinforced concrete. In 1985 he became President of Ball Consulting Ltd. which distributes products and technology to the GFRC and GRG industries. In addition, from 1985 to 1989 he was President of the Pittsburgh Insulating Co., a fabricator and installer of GFRC architectural panels as well as President of Cytonics, Inc. which produced a core material for the FRP industry consisting of urethane foam and fiber glass mat.

Mr. Ball is a member of the Precast-Prestressed Concrete Institute’s GFRC committee, the American Concrete Institute’s 544 and 548 committees and the GRG committee of CISCA. In addition he is a member of ASTM’s C-11 and C-27 committees.