CREATIVE COMPOSITES GROUP

CCG Design and Development and Product Launch Process

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Scope

This document defines the business case, design, validation, and quality assurance processes for all product development and design engineering across the CCG.

Overview

This document aims to cover most aspects of fiber reinforced polymer product or project realization. The intent is to describe the design process and requirements associated with composite products, structures, or systems. The process begins with the business reason to investigate, design, or develop a product or system. The business case shall be developed, documented, and endorsed by CCG sales and or marketing or product development staff and shall have the support at the Director level or higher. The defined, validated and endorsed business case is the first and most important step prior to utilizing engineering resources and starting the design process.

Product/Project Realization/Development Process

Business Case

- Business case evaluation – Has a business evaluation been performed?
    - Is the project aligned with the CCG purpose and strategy as detailed in the CCG Strategic Business Plan?
    - Is the return on investment in line with the CCG requirements as detailed in the Strategic Business Plan?
    - Have preliminary computations been performed to validate the structural attributes are aligned with our material capabilities?
- Cost and gross margin analysis – Have the economies of the finished product been defined?
    - Have the calculations and estimates and quotes been reviewed per the CCG and or Hill and Smith Delegation of Authority Requirements?
    - Are the margins at or above the minimum requirements?
- Sponsor – Is the sponsor clearly defined?
    - Does the project have Director or above endorsement?
    - Who is the Director underwriting the project?
- Sales channel – How will the product be marketed and sold?
    - Direct sales by CCG sales staff?
    - Through a representative network, managed by CCG sales staff?
    - Through a stocking distributor?
    - Other?

Application Requirements that May be Important for Your Project

- Application defined – Define the application and product performance requirements.
- Has the scope of work been defined for the engineering staff?
- Does the project require third party integrated equipment in combination with CCG manufactured products?
    - Has the third-party equipment been through the quality approval process and is it on the qualified products list for purchasing to reference?
    - Does the third-party product need to be developed in coordination with a supplier as well?
- Shipping requirements – Define the shipping method.
    - Any special shipping requirements like oversize loads?
    - Are there special packaging requirements?
- Design life – Has the design life and environment been defined?
- Design codes – Which design codes have jurisdiction?

- Quality requirements – Define internal and external quality requirements.
- Quality validation requirements – Define the internal and external quality and performance validation requirements and processes.
- Shop drawings – Produce shop drawings with tolerances that have been agreed upon by all parties.
- Packaging Scheme – Produce shipping packaging drawings that have been agreed upon by the shipper and receiver.
- Owner's manual – Develop an owner's manual including safety and handling instructions agreed upon by manufacture and customer.
- Maintenance Manual
- Marketing literature and technical data requirements
- Warranties

Defining the Product

Defining what the product is and where it fits in the market is a key aspect of the design and development process. Questions such as the ones below should be considered when determining if a product should be designed. The product definition and requirements shall be undersigned at the Director level and shall be furnished to the design team prior to the start of the project. The project sponsor should have addressed the business case in addition to the questions below, so a clear and concise picture of the product requirements is conveyed to the designer/design team.

- Describe what the product is?
- What need is the product addressing?
- Why is this product different in the market?
- Why will people want to buy it?
- Are there any key barriers to getting this product into the market?
- Is there a key customer pulling this product or is it to be pushed into the market?
- What is the market size? Does that market size justify the costs?
- What types of companies will use the product?
- Why do composites offer advantages for this product?
- What is currently done to solve this problem?
- How long does the product need to last?
- How is the product installed?
- Who typically installs or builds the product or structure?
- What are the routine maintenance requirements and cycles?
- Special provisions?

Design Jurisdiction

Most product designs are based on standard third-party design codes depending on the type of product being developed. These design codes detail the loading and minimum requirements for a product to be used in an application. This needs to be defined early in the design process. Table 1 depicts some common design standards and where they fit in the market:

Table 1

The International Building Code (IBC)	This code touches all aspects of building construction around the world. There are typically slight modifications to this depending on the local jurisdiction, but if it is building construction this code is typically referenced in some way.

ASCE 7	This code defines the loading requirements for buildings in the United States.
AASHTO LRFD Bridge Design Specification	This code defines the loading and analysis requirements for bridges in the United States.
AASHTO LRFD Guide Specification for the Design of Pedestrian Bridges	This code is used in conjunction with the “AASHTO LRFD Bridge Design Specification” and is specific to pedestrian bridges.
AASHTO Prefabricated Bridge Guide Specifications for Design of FRP Pedestrian Bridges	This code is used to define the loading requirements for FRP truss bridges.
Canadian Highway Bridge Design Code (CSA)	This code defines the loading and analysis requirements for bridges in Canada.
Unified Facilities Criteria (UFC)	These are design standards that are published by the Department of Defense that detail the requirements for their facilities. For example, there is one for the “Design: Piers and Wharves” that is commonly used in the waterfront design.
RTP-1	This code defines the design and processing requirements for FRP vessels and is commonly used in the “corrosion” market where the composite product will be exposed to high alkalinity/acidity.
Eurocode	
British Standards	
National Electric Safety Code	
Customer/Owner Specifications	
ADA	
OSHA	
AISC	

This list is not meant to be exhaustive, but to list some common jurisdictional codes. Time should be taken to figure out which codes apply to the product being developed before major design work is done on the project.

Design Loads and Requirements

Nominal design loads, serviceability and deflection requirements shall be documented in the early stages of the design process. These will come from a combination of the design codes detailed above and customer/market requirements. For civil engineering applications the loads will consist of a combination of:

- Dead (self-weight of the product and permanent items in it or attached to it, soil pressure)
- Live (pedestrians loading, vehicle loading)
- Snow
- Rain/Ice
- Wind
- Earthquake/Seismic
- Thermal Strain
- Vibration
- Impact
- Fatigue
- Buoyancy
- Wave
- Flooding

- Vehicle Braking
- Pressure

Note that the inherent properties of composite materials in terms of high compression and tensile strength versus low modulus of elasticity usually result in structures with high strength safety factors since *defection normally controls the design*.

Environmental Effects/Aging

The environmental effects must be well understood. With all environmental exposures there is typically some amount of strength and stiffness reduction over time. For civil engineering applications those effects are well understood, and composites offer exceptional resistance to this type of environmental exposure. The best resources for these strength and stiffness reduction factors is the *Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures.* This standard details the reduction factors for Polyester and Vinyl Ester resins.

For product applications that have exposures outside the civil infrastructure market such as chemical processing and high temperature care should be taken to work with the resin suppliers to determine the suitability and any design reduction factors. For high alkalinity/acidity environments consult the RTP-1 specification for additional commentary.

Temperature

The maximum service temperature for FRP structural members, components and systems shall not exceed T_g - 40°F (T_g - 22°C), in which T_g is the glass transition temperature of the composite system determined in accordance with ASTM E1640.

Composites can take short term temperature excursions above that of the Tg with minimal to no long-term effects. However, when the temperature approaches the T_g strength and stiffness properties reduce significantly. Material rupture, buckling and serviceability limits must be established for composite structures that operate at higher temperatures. Understanding the temperature profiles of the application are critical and shall be considered during the design process. It is not uncommon for surface temperatures to reach 140˚F or more on outdoor structures. The following chart depicts strength and stiffness temperature reduction factors that shall be applied during the design process. Apply the reduction factors to the characteristic design strength and stiffness values prior to performing computations.

Table 2

Reference Property	Temperature (°F) C_T for $(90 < T \leq 140)$
Vinyl Ester Material	
Strength	1.7 – 0.008T
Elastic modulus	1.5 – 0.006T
Polyester Material	
Strength	1.9 – 0.010T
Elastic modulus	1.7 – 0.008T

The above applies heavily to putruded structures and solid FRP laminates. For sandwich panels this only applies if the failure mode is exposed to this higher temperature. For example, the top of a sandwich rail platform panel may reach as high as 140F in the sun, but the failure mode is in tension in the bottom where the sun is not exposed and the foam in the sandwich panel insulates the bottom. For most instances in sandwich panels this section is not used.

Moisture

Moisture uptake reduction factors shall be applied to the characteristic design values prior to performing computations. Moisture plays a major role in strength and to a milder extent stiffness over the design life of a structure. The reduction factors shall be applied during the design process when the structures are exposed to moisture or the elements.

Table 3

Reference Property	Moisture C_M
Vinyl Ester Material	
Strength	0.75
Elastic modulus	0.90
Polyester Material	
Strength	0.75
Elastic modulus	0.90
Add AASHTO MP22 data	

Chemical Exposure via the Liquid or Gas State

C_{CH} = chemical environmental factor (high alkalinity, acidity), determined from interpolation or extrapolation of the results of ASTM C581 tests performed on the laminate exposed to the exposure chemical environment for a period of 1,000 hours, or as stipulated by the EOR. Consult with the resident chemical engineer or resin manufacture to establish the appropriate reduction factors. Note: Pultruded profiles do not perform the same as molded or hand laid composites. The manufacturing process, resin to glass ratio, resin type, and fiber type shall all be considered when establishing the appropriate reduction factors. Temperature can and will accelerate the corrosion process and shall be considered in the design process as well. Do not go out on a limb, back your design assumptions with documented strength and stiffness reduction factors that have been developed for the chemicals and operating temperatures that your project will be exposed to.

UV Exposure

Ultraviolet light (sun) exposure will have a major effect on the surface appearance over time. The rate and extent of surface degradation, due to UV, is based on the intensity and time of the UV exposure. FRP structures located closer to the equator will naturally degrade faster than structures located in Canada. Resin, being organic, will chalk and wash away over time exposing the surface veil and eventually the top fiberglass layers of reinforcement. Resin type and additives play a role in the UV performance but will not mitigate the UV degradation process long term. It is recommended that in addition to UV light absorbers and inhibitors, surface veils and a resin rich surface layer that a topcoat of high-performance paint or clear coat be included in the solution. Contact the resident chemical engineer for the best UV coating for the application.

There have been numerous studies done on the strength reduction from UV effects, but there are no conclusive reduction factors based on the complexity of issue (is it coated, are there surface veils, type of resin, UV additives in resin, etc…). Based on some of this research a good rule of thumb is that an uncoated composite structure will lose about 0.001” per year in average sun exposure. This rule of thumb can be used to determine the structural effects of UV over a specified time. The best defense for composites however is to coat the structure to prevent the UV exposure in the first place.

Design Life

The design life shall be accounted for in the design process via service life reduction factors that apply to the environmental conditions that the finished product or structure shall be exposed to during its intended lifetime. Be sure to document the service life requirements and to apply the appropriate strength and modulus reduction factors. The design life may be further affected by fatigue and possibly the percent of ultimate strength the member or members are worked.

Design for Creep Rupture via Time Effect Factors

Creep (long term exposure to sustained load) may also affect the surface life. To mitigate creep rupture, a time effect factor should be applied during the design process. The following two charts depicts recommended time effect factors dependent upon the load scenario.

Update the chart when LRFD has been finalized

Table 4

LRFD Design Approach		
Load Combination (1.5.2(a))	Equation number	Time Effect Factor (λ)
1.4D (permanent load)	*(1.5-1)*	0.4*
1.2D + 1.6L + 0.5(L_r or S or R)	*(1.5-2)*	0.8 when L is from occupancy
		0.6 when L is from storage
		1.0 when L is from impact
1.2D + 1.6(L_r or S or R) + (0.5L or 0.5W)	*(1.5-3)*	0.75
1.2D + 1.0W + 0.5L + 0.5(L_r or S or R)	*(1.5-4)*	1.0
1.2D + 1.0E + 0.5L + 0.2S	*(1.5-5)*	1.0
0.9D + 1.0W	*(1.5-6)*	1.0
0.9D + 1.0E	*(1.5.7)*	1.0
1.5.2(b) – Flood loads	*na*	0.75
1.5.2(c) – Atmospheric ice loads	*na*	0.75

* It is permissible to use a value of 0.6 if the member is subjected only to compression under concentrically applied axial force

Reference: ASCE Pre-Standard for Load & Resistance Factor Design of Pultruded Fiber Reinforced Polymer Structures; 2010

Table 5

CCG ASD Design Approach	
Load Combination	Time Effect Minimum SF
D (permanent load)	3.6*
D + L	1.8 when L is from occupancy
	2.4 when L is from storage
	1.4 when L is from impact
D + (L_r or S or R)	1.9
D + 0.75L+ 0.75(L_r or S or R)	1.4
D + (0.6W or 0.7E)	1.4
D + 0.75L + 0.75(0.6W) + 0.75(L_r or S or R)	1.4
D + 0.75L + 0.75(0.7E) + 0.75S	1.4
0.6D + 0.6W	1.4

0.6D + 0.7E	1.4
Flood loads	1.9
Atmospheric ice loads	1.9

* It is permissible to use a value of 2.4 if the member is subjected only to compression under concentrically applied axial force
- Chart above assumes a 0.7 resistance factor for all items.

Although the charts below allow FRP structures and/or structural elements to be loaded within 70% of their ultimate capacity CARE SHOULD BE TAKEN ON ANY APPLICATION WHERE THE ULTIMATE STRENGTH IS WORKED INDEFINETELY TO ABOVE 30% OF THE ULTIMATE STRENGHTH (SF<3).

Fire, Smoke and Toxicity Requirements

Structural components and systems shall be designed for fire, smoke, and toxicity requirements in conformance with the applicable building code and or customer requirements. Composites are combustible materials and classified by numerous flammability tests. The most common fire performance requirements in the FRP industry are detailed in the chart below:

Table 6

Testing Standard	Description
UL94	Test for Flammability of Plastic Materials for Parts in Devices and Appliances. Small specimen test that determines the self-extinguishing nature of the composite.
ASTM D635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position. Small specimen test that determines the flame spread of a composite.
ASTM E84	This is the flame spread test used throughout the building code. Specimen is 20in wide by 25ft long with flame exposed to one end. The smoke density and flame spread are measured to determine the “rating”. Class one requires that the flame spread is less than 25 and the smoke density is less than 450.
ASTM E119	This test determines the “hour” rating for a structure, which is used throughout the building code. Test specimen is a 10’ x 10’ and must be the exact construction of the product. For this test a sustained load is applied to the panel, while exposed to flame.
ASTM E136	This is the “non combustibility test”. A small sample is placed in a 750C furnace, and the sample can only lose a small percentage of its weight and not increase the furnace temperature. Composites cannot pass this test unless it is a high fiber content phenolic resin application that uses non foam material.
NFPA 286	This is the corner burn test. Test specimens need to create an 8’ x 12’ x 8’ room mock-up. A flame is placed in the corner of the room and monitored over time for flame propagation.
BS476	British Fire Test Standard

Other than phenolic resin composite structures, hydrocarbon-based resins are combustible in nature and thus add energy to the fire. Most of the testing around flammability of composites classifies the amount of energy released to the fire, how quickly the composite will stop burning when the flame source is removed and the amount of smoke density that is generated from burning. For building applications, the hardest to deal with is the smoke density (black smoke). This prevents egress of people from structures, so this is highly regulated by the international building code.

There are two primary ways that composites are designed to mitigate the effects of this combustibility, smoke generation and flame spread:

Resin Additives – These are typically added to the resin by the resin supplier and can include items like aluminum trihydrate (ATH), bromine or chlorinated organic compounds. The design of this is typically done by the resin supplier, but there are some additives that can added during processing to increase the flame resistance of the structure.

Intumescent Coatings – Intumescent coating is a layer of protective substance which works by chemical reaction generated by heat, resulting in swelling and formation of an insulating layer on the surface, with or without release of water. These typically come in the form of a paint that can be applied to the surface of the composite. When this coating swells it protects the underlying composite structure from the heat.

Fatigue/Cyclic Loading

Fatigue is the repeated nominal loading of a structure. In general composite materials are well suited to resist this type of loading and are typically superior to metals. With fatigue loading it is critical to understand the typical service load versus the ultimate capacity of the composite. When the typical service load is less than 50% of the service load (SF>2) it should be expected that the composite should last more than 1,000,000 cycles. When the service load exceeds 50% of the ultimate capacity additional investigation should be undertaken.

When the service load varies on a structure a weighted average of that service load should be utilized for the testing. For example, a vehicle bridge deck has vehicles that may range from 3,000lbs to 72,000lbs since most of the vehicles are cars it would be a reasonable assumption that the weighted average vehicle weight may be close to 8,000lbs. This value would be the one used for fatigue testing.

Thermal Expansion

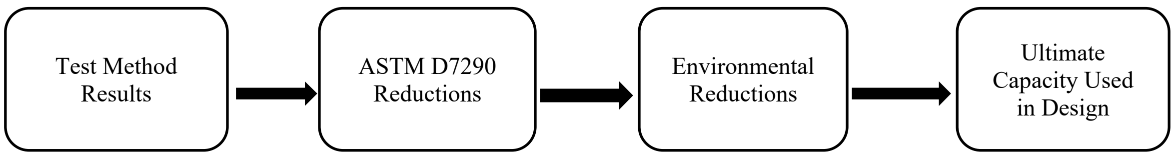
Thermal expansion and contraction are a key component of any design, composites are no different. Thermal expansion in composites is primarily driven by the fiber type and orientation. Fiberglass composite made from pultrusion, and vacuum infusion have high fiber volume fractions and have similar thermal expansion characteristics to that of steel. The key item to remember with composites is the thermal expansion coefficient is typically different in the 0° and 90° direction and can range from 4×10^{-6} $°F^{-1}$ to 12×10^{-6} $°F^{-1}$.

Care should be taken to not introduce thermal strain into the design where it can be avoided. Thermal strain results when the composite structure it fixed in place in a way that restricts the movement of a structure. This can typically be avoided by providing appropriately sized slots in key connection points.

One other phenomenon that composites are particularly prone to (especially foam filled sandwich panel designs) is that one surface of the structure heats up with the sun or other heat source and because of the insulative nature of the structure the other side is significantly colder. This results in the warm side expanding more than the cold side and can cause the structure to curve. This should be accounted for in the design.

Strength Design Input Values Associated with FRP Materials

Strength design input values for established products and or standard fiber architectures and stacking sequences, shall be determined based on ASTM protocols and the data shall be reduced to the average and characteristic design strengths and moduli per ASTM D7290. When possible, utilize existing fiber architectures with predetermined characteristic design strengths when possible. If an alternative fiber architecture is required for your project, it is best practice to build prototypes and to determine the characteristic design values prior to final product realization in which final geometry has been established. The typical process for determining the ultimate capacity used in design is shown below:



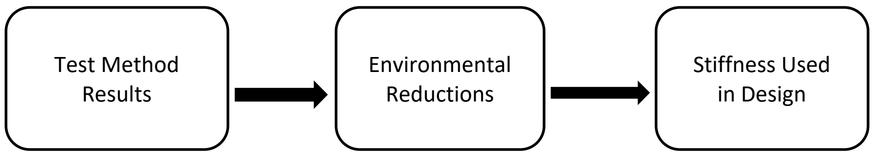
The typical ASTM mechanical test methods that are used to generate the design properties for composites are detailed below:

Table 7

Test Method	Description
ASTM D638	Testing method to determine the tensile strength of both reinforced and non-reinforced plastics. This protocol is performed on "dog bone" shaped samples and under different pre-treatment, temperature, and humidity conditions as per the different speeds of the testing machine.
ASTM D3039	Testing method to determine tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus.
ASTM D6641	Testing method to determine the compressive strength and stiffness properties of polymer matrix composite materials using a combined loading compression (CLC) test fixture.
ASTM D953	Testing method to determine the pin bearing strength of rigid plastics.
ASTM D695	Testing method to determine the compressive strength of rigid unreinforced and reinforced plastic. The specification was put in place to ensure that consumers are getting what they pay for when they purchase a product.
ASTM D5379	Testing method to determine the in-plane shear properties of composite materials.
ASTM D7078	Testing method to determine the in-plane shear using the V-notched rail shear testing method that is widely used to determine the in-plane shear characteristics of composite materials.
ASTM D2344	Testing method to determine the interlaminar strength of high-modulus fiber-reinforced polymer matrix composites
Bolt Pull Through	

Design for Serviceability (Deformations/Stiffness)

Structural analysis shall be based on *mean values* with environmental reductions for the elastic modulus and in-plane shear modulus. The typical process for determining the stiffness capacity used in design is shown below:



For analysis that does not allow for differentiated tension and compression elastic moduli the lower of the two values shall be used in the design. Stiffness values shall not be multiplied by the time reduction factors. When designing for serviceability, the shear modulus can be neglected on spans with a span to depth ratio above 20:1 since the shear contribution to deflection is rather benign. However, when designing deflection sensitive products or structures, shear deformations and long-term creep effects vs time shall be considered in the design.

Rule of Mixture

Rule of Mixtures for the lengthwise direction is a method of approach to approximate estimation of composite material properties, based on an assumption that a composite property is the volume weighed average of the phases (matrix and dispersed phase) properties. This methodology can apply to a lot of aspects of the design process.

> *Molded Parts* – With molded parts typically only lamina is tested (lamina is the test result of a specific type of fabric versus the testing of a specific stacked up combination). The rule of mixture is used to create the laminate (laminate is the stack up of several laminas) properties through the rule of mixture.
>
> *Pultruded Parts* – With pultruded parts VectorPly design software can be used to estimate the properties of products and lamina sequences that have not been previously characterized.

Composite Design References

There are numerous additional resources that deal specifically with the design of FRP structures and include the following:

Table 8

Resource	Description
CPI Pultex Design Manual	Design guide created by Creative Pultrusions.
Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber	AASHTO design guide specific for pultruded FRP structures.

Reinforced Polymer (FRP) Structures 2010	
RTP-1	This code defines the design and processing requirements for FRP vessels and is commonly used in the "corrosion" market where the composite product will be exposed to high alkalinity/acidity.

LRFD/ASD Design Approach

There are two primary design methodologies that are utilized by structural engineers.

Load & Resistance Factor Design (LRFD) – LRFD provides a probability-based mechanism to select load & resistance factors. In this approach the design load is factored up and the ultimate capacity of the structure is reduced. If the reduced capacity can handle the increased load the structure is deemed acceptable therefor there are NO SAFETY FACTORS in LRFD design. The safety factor is baked into the combination of load factors and resistance factors. For example, if the live load is factored up by 1.6 and the capacity has a resistance factor of 0.8 the implicit safety factor of this condition is 2 (1 / (1/1.6 * 0.8)).

Allowable Strength Design (ASD) – ASD compares the actual load to the design strength of the structure in question. In this approach load cases are reduced to simple safety factors. The appropriate safety factors vary depending on the type of loading. Industry accepted safety factors for pultruded profiles and structures are typically 2.5 for members in bending and 3.0 for members in shear and connections.

Calculation Methods

There are two primary calculations methods that are utilized throughout the composites industry: hand calculations using predetermined equations and finite element analysis (FEA).

Hand Calculations – Hand calculations are the most used method for determining the adequacy of the design. There are thousands of different hand calculation equations for determining just about any design consideration. When using hand calculations there are assumptions that are made in deriving the equations that the designer should be aware of:

- Beam bending – traditional beam bending equations ignore the contribution of shear deformation to the overall deflection of the structure. In composites, shear deformation contributes to the overall deflection of structure much more than with steel. Typically shear deformation is still a small percentage of the overall deflection except in shorter span applications.
- One way loading – for all equation-based analysis it does not consider two-way loading. If this two-way loading is a significant factor in the design FEA may be a better design choice.

Finite Element Analysis – FEA is a computer simulation of the structure and loading inputs. This type of analysis is highly accurate in determining the stress distribution and movement of a structure. The creation of these models needs to be done by a professional that has training and experience in creating the models. It is also critical that accurate properties be input into the model, which can be complicated.

Design Validation

Your final design shall be validated by comparing the mechanical and physical requirements of the finished product or structure to the manufacturing, materials, and overall organizations capabilities. In some instances, this may be documented as part of a control plan which can be used as part of the submittal package and for internal quality and manufacturing communication. When feasible, full-scale testing should be performed to validate the design methodology. This process involves documenting all aspects related to form fit and function and documenting the design and manufacturing controls necessary to validate compliance to the project scope, specifications, general and special provisions. Pushing the design envelope and the organizations capabilities shall be done with caution. All risks associated with "new" applications and requirements shall be documented and a risk mitigation plan executed. The risk plan shall identify all the "risks" and describe the plan to mitigate the risk.

Manufacturing Quality Assurance and Validation

Given the opportunity, design possible quality issues out of the equation. Design the finished product dimensions and fabrication well within our manufacturing tolerance capabilities. Dimension holes and cuts from a datum point that can be used in the shop with calibrated "normal" tools of the trade to measure and fabricate from.

Your final product or structure design should include a list of critical dimensional and mechanical properties or other key attributes that are paramount for the system to perform as designed. These critical elements, as well as, the resin series, fire requirements and color, to name a few, should be documented in the advanced quality plan (AQP). The AQP should effectively communicate, to all facets of the organization, especially, manufacturing, engineering, and sales the mechanical and physical and commercial requirements of the product or system. An example of an advanced quality plan with instructions can be viewed in appendix A.

The advanced quality plan shall be filed on the company server as described in the company AQP procedure. The AQP permits manufacturing engineering, design, sales and quality control to have a centralized location and document that all can reference so there are no assumptions as to the customers' requirements and expectations. The AQP can also be described as the "voice of the customer".

Structural Design Drawings and Specifications

The structural design drawings and specifications shall clearly show the work that is to be performed and shall give the following information with sufficient dimensions to convey the quantity and nature of the pultruded FRP composite shapes to be fabricated:

a) Size, section, material and location of all members
b) All geometry and working points necessary for layout
c) Floor elevations
d) Column centerlines and offsets
e) Connection locations and fastener details, if required by the contract documents
f) Identify what CCG is providing versus others

The structural design drawings shall show permanent bracing, column stiffeners, bearing stiffeners in beams, web reinforcement, connections and other items at sufficient scale and detail that their quantity, detailing and fabrication requirements can be clearly understood. Any special requirements for camber that are necessary to bring a loaded member into proper relation with the work of other trades shall be set forth in the design documents.

Insurance Requirements

When working with a third-party engineering firm on a consultant basis the professional engineering firm must be an approved vendor and must carry a minimum amount of insurance as described in Appendix B with proof via a certification of liability insurance. The certification shall be kept on file and shall be updated yearly. Purchase orders for third party engineering shall be placed by CCG purchasing at the request of the CCG project engineer.

Liability Disclaimer

As a solutions-oriented organization, engineering staff performs computations that are sometimes gratuitous in nature and are required to validate to the prospect that the proposed solution will work for the application. When gratuitous computations and designs are supplied to a prospect or customer, it is up to each CCG engineer to note that the computations are in fact gratuitous in nature and are being supplied with no liability. Therefore, a liability statement shall be included with the design submittal and or design correspondence which reads as the liability statement found in Appendix C.

Engineering Review Process

All computations performed internally shall be reviewed by a peer or supervisor and a written validation acknowledging the review and approval to transfer the document to a prospect or client shall be retained via e-mail or in the form of a signature and date on the actual calculations. An association to the exact document with the title, date and latest revision date shall be documented on the approval to transmit email. The e-mail shall be filed in the project folder and saved on CCG servers. It is good practice to limit the liability with the use of third-party engineering firms. If third party PE seals are not contractually required, depending on the complexity and dollar amount of the job, you should consult with your supervisor regarding hiring a third party EOR to review and seal the job.

Engineering Change Orders

All engineering change orders shall follow your documented process with the appropriate delegation of authority sign offs. All change orders shall be documented, disseminated, tracked and retained as defined in the engineering change order procedure.

Document Control

All CCG companies shall have a document control procedure. An example of control of documents procedure can be found in the appendix.

Non-Disclosure Agreements (NDA) and Obligations

All company employees that communicate with clients and resin supplies shall be made aware of non-disclosure obligations by identifying all NDAs that are kept on file. No one shall disclose, outside of the group, any information pertaining to or about the parties with whom the NDAs are filed.

White Paper Development

All CCG technical staff are encouraged to document knowledge known, advanced and discovered using white papers. The white paper shall be written describing the issue, the testing and engineering used to address the issue, the results and how the information should be used. The White papers shall be stored so all technical and sales staff have access to the white papers. Some white papers may be developed in support of marketing literature development and act as validation of the mechanical and physical properties that are detailed in technical brochures. Marketing shall control all white papers. White papers shall be developed in word format and then sent to marketing for final grammatical edits and filing.