1.0 Scope of Services

2.1 Task 1: Competition Understanding

The big beam competition is setup with a variety of judging categories. These judging categories each contain a great amount of description, which is why understanding how the competition will be scored is crucial.

2.1.1 Task 1.1 Loading Conditions

The loading conditions for the 2018-2019 competition has changed from the previous year's guidelines. The location for the two point loads is no longer at midspan. The two point loads have shifted to the right, which effects the calculations required.

2.1.1.1 Task 1.1.1 Determination of Max Moment

With the shift of the point loads, the maximum moment seen in the beam for this setup will be less than the maximum moment of a beam with centralized point loads. This new addition to the competition guidelines will affect the overall design of the beam structure.

2.1.2 Task 1.2 Competition Scoring

There are seven categories that have a role in the overall scoring process. The category with the most points associated with it deals with the design accuracy. The next three categories, are based on the results of the other competing teams. Two categories are awarded based on the judge's thoughts on the report quality, the practicality, innovation, and compliance with code.

2.1.3 Task 1.3 Material Specification

The beam and concrete designs need to follow the ASTM and ACI 318-14 regulations.

2.1.4 Task 1.4 Testing Specification

Concrete mixes will need to be tested and follow all ASTM testing regulations. A PCI producer member will also be needed to confirm these standards were followed during the the testing of the beam.

2.2 Task 2: Beam Design

The bulk of the work for this project is to create the most optimal design to meet all judging criteria. The three main components included into the optimal design are the concrete mix design, and the cross sectional shape design, and the pre-stress/reinforcement design.

2.2.1. Task 2.1: Mix Design

2.2.1.1 Task 2.1.1 Portland Cement Type

The cement will have a major factor on the overall strength and attributes of our concrete mix. There are five major types of Portland cement, with different proportions of silica, calcium oxide, alumina, and iron oxide for the major components. The choice of cement will impact the heat of hydration chemical reaction (cure time) and will also have an impact on the concrete mixes compatibility with admixtures.

2.2.1.2 Task 2.1.2 Aggregate Type and Gradation

The choice aggregate, size, and shape will have a major impact on the overall strength of the concrete. A variation of gradations consisting of coarse sized aggregate of up to a maximum size of ¾ of an inch, combined with fine aggregates smaller than ⅜ of an inch. The aggregates overall will account for 60 to 80 percent of the total mix. The use of locally available aggregates will make our concrete mix more economical and practical.

2.2.1.3. Task 2.1.3 Water to Cement Ratio

The water to cement ratio is an important factor in mixing concrete. Potable water, that doesn't have an odor, can be used to make the Portland cement paste. This will impact the workability, cure time, and strength of the mix.

2.2.1.4 Task 2.1.4 Additional Admixtures

The use of chemical and/or mineral admixtures can be used in the mix design. Pozzolanic materials are popular mineral admixtures that are the by-product of industrial processes, such as fly ash or slag. Pozzolanic materials act as a partial substitute for Portland cement, which makes use of waste products and reducing manufacturing cost. Chemical admixtures can be added to control the heat of hydration process, improve workability, and decrease shrinkage or cracking.

2.2.2 Task 2.2 Material Testing

2.2.2.1 Task 2.2.1 Acquiring Materials

Materials for mix design will be acquired from Cemex. Once materials are available, different mixes will be casted for testing.

2.2.2.2 Task 2.2.2 Casting Test Cylinders

Test cylinders will be casted with our designed mix and collecting commercially standard test cylinders from Cemex. These test cylinders will be in two different sizes, such as 4 by 8 inches or 6 by 12 inches. The testing of a minimum of four cylinders for each concrete mix will be performed. The test results will provide the 3 day compressive/tensile strength and 28 day compressive/tensile strength of the concrete mix.

2.2.2.3 Task 2.2.3 Split Cylinder Test (Tensile Strength)

ASTM C496 will be used to test the tensile strength of concrete. This is achieved by laying the test cylinder on its long side and loading the cylinder at the tip of the circular side of the cylinder. This load will apply internal stresses of tensile force to the cylinder until failure. Concrete is very weak in tension but tensile strength of the mix is needed to determine the amount of reinforcement.

2.2.2.4 Task 2.2.4 Compression Test (Compressive Strength)

ASTM C39 will be administered for the compressive strength of each mix. This lays the cylinder on its flat circular side and loads the test cylinder in compression for failure. The compressive strength is critical for accurate structural analysis.

2.2.2.5 Task 2.2.5 Mix Design Finalized

The team will determine whether or not the design created will be used for the final beam design. The team will also compare the results from our testing with respect to TPAC ready mixes.

2.2.3 Task 2.3 Geometrical Analysis

2.2.3.1 Task 2.3.1 Mathcad Programming

Structural analysis and calculations that need to be performed for the beam design will be performed using Mathcad. Mathcad is a computer software that is similar to excel, though Mathcad is easier to read and display work. Mathcad will be formatted to determine the required calculations for different beam cross sections. The use of the section properties for each cross section will be used for the following calculates:

- Moment of Inertia
- Cracking Moment
- Nominal Moment
- Deflection
- Moments Due to Stressing
- Moment of Prestressed
- Modulus of Rupture
- Transform Section Approach
- Prestress Losses
- Service Performance

All calculations on Mathcad will also be ran using the software, Response 2000. This software determines the strength of a concrete beam with respect to different load types like shear and moments. The results from the analysis will then be used to determine the reinforcement layout. The rebar grade and prestressed cable size will need to be chosen to design a beam that will meet the requirements for the competition.

2.2.3.2 Task 2.3.2 Decision Matrix

The decision matrix uses a scoring system that breaks up the characteristics of the concrete mixture and geometrical design. Mix design is a complex balancing act with many conflicting variables, every ingredient chosen for the mix will come with an advantage and a disadvantage. The decision matrix will allow the team to determine which concrete mixture performs best with our reinforcement design at the lowest weight, highest compressive capacity, lowest cost, and highest deflection.

2.3 Task 3 TPAC Manufacturing

2.3.1 Task 3.1 Finalize Beam Design for Shop Drawings

The final design of the beam will be used to create a shop drawing on AutoCAD and will be submitted to TPAC to manufacture.

2.3.2 Task 3.2 Shipping

The beam requires a 28-day curing time before the beam can be shipped to the testing location at Northern Arizona University in Flagstaff, Arizona.

2.4 Task 4 PCI Big Beam Final Testing

2.4.1 Task 4.1 Predict Results

The predicted values for our beam design will need to be given to a third party member. This will ensure that no modifications can be made to the prediction values.

2.4.2 Task 4.2 Test Beam

Testing of the beam will be done at Northern Arizona University 28 days after the beam is casted by TPAC.

2.4.3 Task 4.3 Make a Video

A video is required to be submitted displaying the highlights and failure for verification purposes of the test. Visible scales showing the beam deflection need to be visible in the video provided.

2.5 Task 5 486 Deliverables

2.5.1 Task 5.1 Final Report

A written final report will be provided of the methods used for analysis, as well as results from the testing of the beam.

2.5.1.1 Task 5.1.1 30% Submittal

A 30% report will be written establishing the methods used for the analysis of the geometrical cross section and concrete mix design.

2.5.1.2 Task 5.1.2 60% Submittal

The 30% report will be upgraded into a 60% report by adding recorded data that was collected from the beam testing.

2.5.2 Task 5.2 Website Design

The final website will showcase the final design, report, and testing of the beam.

2.5.3 Task 5.3 U-Grad Presentations

The final presentation will display the team's final product to the capstone instructors, faculty on campus, and to any stakeholders who have interest in the competition results. This is the chance for our team to share our results in a professional setting, and defend our final design.

2.6 Task 6: Project Management

2.6.1 Task 6.1: Project Management

2.6.1.1 Task 6.1.1 Technical Advisor Meeting

The team will meet with the advisor every week to discuss progress on both the beam design and the concrete mixture

2.6.1.2 Task 6.1.2 Grading Instructor Meetings

Each meeting with the grading instructor will take place prior to deliverable submissions in order to receive input, and afterwards to solicit the appropriate feedback.

2.6.1.3. Task 6.1.3 Team Meetings

The objectives of the team meetings include: discussing the week's agenda, completing the applicable deliverables from capstone and the technical advisor, and updating each other on the progress towards final testing.

2.6.1.4 Task 6.1.4 Scheduling

A schedule will be generated into a Gantt chart and will be followed accordingly. The generated Gantt chart will also be update throughout the project to establish current progress of the project.

2.6.1.5 Task 6.1.5 TPAC Communication and Beam Transportation

Communication will need to be consistent with TPAC to ensure that the beam will be manufactured by the desired delivery date. Communication with a shipping company will also need to be established in order for the beam to be properly transported to the testing location at Northern Arizona University in Flagstaff, AZ.

2.6.1.6 Task 6.1.6 Billable Hours

Hours spent working on the design for the beam will be recorded and billed accordingly.