CE 487 Senior Design Project

# Lightweight Concrete Mix Design for Thin Wall Structure

**Group Members:** Race Anderson, Dominic Hood, Noah Finefrock, Trevor Lickey, Adron Howard

**Problem:**

Typical concrete mix designs used in construction (the most accessible mix designs) are not practical for use in the fabrication of buoyant marine devices as they incorporate strong, dense materials to achieve high compressive and tensile strength. While readily available, typical mix designs exceed the required density for flotation, rendering them useless for a thin-walled concrete structure such as a canoe. Instead, a specially designed lightweight mix design is required to successfully and properly create a buoyant device capable of floating whilst fully flooded.

**Requirements & Specifications/ Given Parameters:**

Requirements and technical specifications for materials for the design of the concrete mix are stated in the ASCE Concrete Canoe Competition 2026 Request for Proposals, Exhibit 5.

- The ratio of total measured thickness of primary reinforcement to the total thickness of the canoe wall or structural element at any point of the canoe shall not exceed 50%.
- Limit of a total of three concrete mix designs.
- Primary reinforcements shall be covered in concrete
- All concrete mix designs shall have an oven-dried unit weight less than 80.0 PCF
- Hydrated Lime may be used when limited to 5% by mass, and the combined total of hydraulic cement and hydraulic lime must not exceed 40%. Quicklime is not permitted.
- The maximum amount of hydraulic cement in any concrete mixture must not exceed 40%, by mass, of the total cementitious materials content.
- Any type or combination of hydraulic cement may be used, provided it meets the appropriate correlating ASTM standards.
- Aggregates of natural, manufactured, or recycled sources must constitute a total volume of at least 35% of the total volume of any concrete mixture

- No limits of aggregate gradation are required but must be reported in a size distribution table for each individual aggregate received following ASTM C136 procedures.
- Fibers shall meet ASTM C1116 requirements and be considered as secondary reinforcements
- Admixtures must comply with appropriate correlating ASTM standards and submitted in MTDS documentation
- Latex emulsions can be used as solid powder or dehydrated liquid of no more than 100 lb/CY of concrete. They should meet ASTM C1438 Type II requirements and not use other bonding adhesives.
- Solid content of dyes and powder admixtures must be included in the determination of the total solids content.
- The minimum percent open area of any layer of reinforcing material is 40%.

**Design Variable:**

The selection and proportions of all cementitious materials, lightweight aggregates, and admixtures used in the lightweight mix design can be controlled as they contribute to the unit weight, strength, and buoyancy of the canoe.

**Limitations & Constraints:**

The limitations and constraints of this project accommodating to the requirements and specifications above are:

- The project is limited to the amount of money the group can gather from sponsors.
- The concrete mix is to be selected by November 20$^{th}$ giving less time to research due to testing time dependency.
- Access utilities such as materials used for the concrete mix and dependency on lab technicians to work in the Concrete Lab.

**Additional Considerations:**

In addition to the above criteria, the concrete design and fabrication must follow the listed ASTM and OSHA standards:

- **ASTM C330/C330M-23**- Standard Specification for Lightweight Aggregates for Structural Concrete:

    - Discusses use of lightweight aggregates in structural concrete in which the aim is to reduce density of the overall mix while maintaining compressive strength.
- **ASTM C39/C39M-21** – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens:
    - Discusses the compressive test method for concrete mix designs that exceed 50 lb/ft^3
- **ASTM C567/C567M-19** Standard Test Method for Determining Density of Structural Lightweight Concrete:
    - Discusses standard test methods for determining the oven-dry, and equilibrium density of a concrete mixture.
- **ASTM C494/C494M**: Standard Specification for Chemical Admixtures for Concrete:
    - Covers chemical materials to be used as admixtures in concrete mix design as well as their corresponding test methods.
- **29 CFR 1926.1153**: Respirable Crystalline Silica:
    - Discusses safety concerns and procedures related to respirable silica exposure during any kind of work with cement/concrete.
- **29 CFR 1910.1200**: Hazard Communication:
    - Covers proper transmiattal of chemical related safety concerns and precautions by means of hazard communication programs (safety data sheets, container labeling, & employee training).
- **General PPE Requirements 29 CFR 1910**
    - PPE requirements for work with different machinery or materials can be found under standard 1910