

## ARCH 614. Cardboard Swing-Couch Design

**Dates:** Part I during class on 1/29/13 Building B Exhibition Space  
Part II due 4/16/13

*Pass-fail work*

### Problem Statement for PART I:

The design involves the construction of a hanging structure of original design, constructed only of recycled single-ply corrugated cardboard, cloth, rope, and glue. The design is to be documented by a 4 page report that includes 1) a list of materials and quantities (*measured areas*) used, 2) an elevation drawing, 3) a side elevation drawing, 4) a plan drawing, 5) a cardboard joint detail drawing, 6) a short narrative of the design process, how it meets the specified criteria, and the construction process, and 7) a brief discussion of the anticipated behavior (deflections, flexing, etc) when loaded with sitting people.



The structures must permit two class members (to be designated) to sit upright *facing forward* without tipping or collapsing.

The project report and construction is to be completed with a team.

EVERYONE MUST BE PHOTOGRAPHED with their design (digitally). To identify each team, a sign must be displayed with the name of the entry noted in very readable block lettering in the photograph. The sign is to be no larger than letter size paper.

### Rules:

1. Each team will be allowed to use corrugated cardboard, cloth or canvas, rope, and glue of any kind. Laminating (layering cardboard sheets with glue) is strictly prohibited. No tape or mechanical fasteners will be permitted. Pre-manufactured tubing is also prohibited.
2. The structure is **not** to be assembled on the day during class. The components must be prefabricated, partially or fully assembled and transported on the day to the test site.
3. The structure will be subjected to two loads of approximately \_\_\_\_\_.
4. The structure **must** have cardboard members that the ropes and cloth are attached to provide stiffness, particularly for the seat base.
5. The chair must elevate the loads off the ground for an extended period of time, and the chair back may not tilt more than 30° when loaded or unloaded.
6. Each seat of the couch can be no smaller than 455 mm x 405 mm. The seat area must consist of a perimeter frame and a cloth base. Only one frame member is permitted within the perimeter and must be between the seats. *Any surfaces must be constructed of cloth. No flat sheets of cardboard are permitted for seats or seat backs.* The frame cross section (*through the member*) must not exceed the boundary of a 100 mm x 75 mm rectangular area. The seat frame members must be visible enough to permit observation.

7. Each seat back can be no smaller than 455 mm x 435 mm. It may or may not have a frame, but again, any flat surfaces must be constructed of cloth and cannot be constructed of flat cardboard sheets. Arm rests are permitted under the same restrictions, but must be no taller than 200 mm.
8. The couch bottom, when empty, must be no higher than 500 mm above the ground surface, and cannot be lower than 350 mm off the ground surface when occupied.
9. The couch can be no wider than 1.8 m to fit within the swing frame.
10. The couch must be suspended by no less than 3 contact points and no more than 6 contact points with the rope to the support frame. Rope may be used anywhere in the structure *except in the seat base*. The ropes must be the correct length needed to satisfy Rule #7 when the carabineers to clip onto are 1.7 m above the floor. The ropes must have loops or clips **in place** (*no adjustments allowed*). Stretching of the rope must be anticipated as well.
- 11. The couch cannot be constructed in any studio in the Langford Architectural Center without a signed statement from the studio professor allowing it and an affidavit certifying that all construction waste has been properly disposed of. Use of “cold” studio desks is strictly forbidden without this pre-approval and post-verification of proper studio use. \*Any project not properly disposed of will receive a failing grade.**

### Objectives:

The primary objective of the project is to construct a structure that will be subjected to loads of gravity, behavior of materials by shape and strength, and that LOOKS GOOD. The secondary objective is to work on a construction team, and produce a unique corrugated cardboard structure. In addition, the design-build will be advertised to, visible to, and scrutinized by the College of Architecture.

### Evaluation Criteria:

1. Completeness (30%)
  - a. Have you included the required report items? Is it easy to read and understand?
  - b. Have you followed the specifications given in Rules?
  - c. Do your behavior predictions have any basis in reality?
  - d. Are the cardboard materials quantified by area, not number of sheets?
  - e. Do the plan and elevations drawings have dimensions? Is the cardboard joint detail sufficient to identified location and assembly method? Are the locations of the rope and connections on the drawings?
2. Design Quality (35%)
  - a. Does the couch meet or exceed the minimum requirements for function?
  - b. Are the materials used appropriately?
  - c. Is too much material used?
  - d. Does it look pleasing or scary or “cookie-cutter” like?
3. Construction Quality (35%)
  - a. Was the work performed at the last minute or thought through before construction?
  - b. Is sufficient quantity of material used or connections reinforced where needed such that it will not come apart when used?
  - c. Is it painted up to cover any construction or material flaws?
4. Above and beyond (5% or more)
 

*This section is included for innovative and creative content or quality that I have not explicitly asked for.*

**Problem Statement for PART II:**

The constructed couch swing design of part I is to be analyzed and evaluated using structural principles. The design must be revised, but will not be constructed. Revision means material and construction changes based on the evaluation (and NOT changing colors, or rope lengths, etc.) The team will produce a document of the as-built analysis and revisions with the analysis process and evaluation documented as a team to model static structural behavior, classify connections, and quantify capacity based on experimental evaluation of the material.

- Drawings with parts to scale are to be provided in the document for the as-built design and the revised design.
- Structural load values and placement from the testing of the original design are to be documented and used for analysis. Calculations for the loads, moments, stresses, and deformations of key structural members and connections should be provided for the original and revised design. Evaluation of the capacity of these elements must be provided and documented. Multiframe software is useful for this analysis.
- Mechanical tests for stress and strain of the cardboard material should be performed and documented.
- Decisions for the revision and evaluation of the revised design must be documented in the context of improved performance from that of the as-built design.

A paper report of sufficient length to cover the content required will be produced.

**Objective:**

The objective of the analysis, evaluation and re-design is to apply the principles of structural behavior, analysis, and design to a physical object that performs a structural function. Discussion and evaluation of the *architecture* of the construct is expected. The reports are to be informative as well as interesting.

**Assessment Criteria:**

The project outcomes must meet the items listed in the problem statement. In addition, depth of reflection on architectural aspects of the structure will benefit the assessment outcome. The assessment will be weighted based on completeness, modeling quality, and evaluation quality.

The project report is a team effort, and will be graded as such. Overall quality and breadth will be reflected in the report. Team members should clarify goals and outcome together, but all work will not necessarily be conducted together. Team members should delegate research assignments or tasks so as to work productively. Input on the effort of individual team members will be solicited from the team themselves.

The report must have the minimum content:

Introduction: This is the section that sets up the story. It is usually a brief description of what you are going to tell the reader.

Background: Any research related to cardboard construction that is relevant to the main discussion should be presented here.

Main Body: This section can have any relevant title and multiple subsections. It should include a description of the as-built couch swing of part I including as-built drawings. The load magnitudes and locations during the “test” must be identified. A detailed description of the behavior under loading, including deformations and any observed high stress locations or failures, must be provided. There must be a *quantitative* evaluation of the loads/reactions using Multiframe software.

The description of the limitations of the original design must be related to the evaluation of the structural performance (i.e. maximum forces or moments or deflections and locations). Testing to quantify stress and deflection capacity of the cardboard or built-up shapes must be performed and documented. The revisions and decision process for the revisions must be documented with respect to structural design requirements. A *quantitative* evaluation of the structural behavior must be performed with Multiframe, and comparisons described, preferably showing improvement in the structural performance.

A list or description of figures should be included along with the required drawings.

Conclusion or Summary: This section must summarize the key points from the story. It is usually a brief description of what you just told the reader/viewer.

### **Evaluation Criteria:**

1. Completeness (30%)
  - a. Have you included the required report items? Is it easy to read and understand?
  - b. Do the plan and elevations drawings for both as-built and new designs have dimensions?
  - c. Is there analysis of both as-built and new designs?
  - d. Is there evaluation of both or comparison?
2. Modeling Quality (35%)
  - a. Are the model dimensions the same as the as-built couch, and are the member connections and types accurately represented in the model?
  - b. Are the materials identified for each part of the as-built couch?
  - c. Is the load quantified and is it appropriately put on both couch models?
  - d. Is there a discussion of the location and the magnitudes of the critical forces and stresses including values and referenced figures?
3. Evaluation Quality (35%)
  - a. Are the results from the modeling compared to material strengths, and is there a discussion of efficiency based on those results for both models?
  - b. Are the results from the modeling compared to serviceability requirements, and is there a discussion of deformations for both models?
  - c. Is the relationship to the structural requirements and the architecture discussed?