



SKANSKA

ASC Student Competition

**Reno, NV
February 10-11, 2022**

Open Competition:
Sustainable Building

Welcome to the 2022 ASC Open Competition Sustainable Building Problem Statement!

We are excited that you've chosen to compete in this problem category. Skanska continues to be an industry leader in sustainable construction. We strive to create projects that have minimal impact on the environment throughout their construction and lifecycle. Sustainable construction continues to expand and encompasses a wide reach of topics including reducing waste, resiliency, carbon neutral practices, and occupant well-being. In participating in this problem statement, we hope that you will gain a better understanding and appreciation of the green building methods that the construction industry can employ in our day-to-day operations. More than that, we hope that you will look to implement these ideas into your careers and daily lives outside the workplace.

This year, we've formatted the problem statement as a Request for Proposals (RFP) for on-call sustainability consulting services. The Skanska Problem Statement Team will act as the selection committee from the Federal Department of Transportation. Your written submission Thursday will be your team's proposal response, and Friday presentations will be your interviews.

Good luck! We hope you enjoy this problem statement we've assembled for you.

Sustainable Building Problem Statement Schedule

Thursday, February 10, 2022

6:30am	Introduction in Southern Pacific EF, and Issue RFP via Procore
11:30am	EC3 Presentation in Southern Pacific EF
5:00pm	RFI Deadline via Procore
9:00pm	Proposals due via Procore
9:30pm	Issue Interview Notice via Procore
11:00pm	RFI Deadline for Interviews

Friday, February 11, 2022

7:00am	Presentation materials due via Procore
8:00am	Presentations start in Southern Pacific EF
6:00pm	Problem Statement Recap in Southern Pacific EF
7:00pm	Skanska Hospitality Event in Southern Pacific EF

Saturday, February 12, 2022

12:15pm	Awards Ceremony
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ASC Competition Rules

- Student teams must comply with the published ASC Competition Rules (revised 8/20/21).
- Once the kick-off meeting concludes, and until a team's oral presentation is completed, only the students identified as being team members shall be present in the team's room(s) or shall collaborate on the team's response to the problem statement. No additional person(s) may perform as a helper, runner, or assistant for any team for either the regional or open competitions. Teams will be disqualified if any team has more than 6 members participating in the process of creating a competition solution in any way. This includes food and supply runs! The use of cell phones to contact outside persons is not permitted except in an emergency or as deemed appropriate by the problem sponsor. Faculty advisor(s) may not interact with their teams once the competition has begun.
- Use of the internet is allowable and may be necessary for certain components of the problem.
- No phone calls or emails may be made to the Owner, Construction Manager, Architect, Civil, or Structural Engineer, or any other design consultants listed on the Drawings. Similarly, no components of the problem may be sent to others outside the team for assistance in completing the problem.
- A one-half (1/2) point deduction will be taken for each minute that the solution statement is turned in past the time that it is due. Solution statements are due **Thursday at 9:00pm PST via Submittals in Procore**. If internet issues arise, solutions can be submitted on a USB drive in the Southern Pacific EF room. The 9:00 pm deadline and point penalties listed above apply to USB submission as well. Other deliverable items, if applicable, will be due as specified. All teams should still meet in Southern Pacific EF at 9pm to get oral presentation time assignments.
- The oral problem statement (Interview Notice) will be released at 9pm Thursday night. Presentation times will be determined Thursday evening. Presentation materials should be uploaded to Procore by the deadline Friday morning. Skanska will provide the computer with all presentation materials for each team. No additional materials are allowed to be distributed or presented. Any additional equipment required for a presentation is the responsibility of the team.
- While the judges will endeavor to administer the problem with all fairness and appreciation for the team's perspectives, the decisions of the judges shall be final when deciding conflicts and scoring.

Request for Proposal Guidelines

Requests for Information:

RFIs will be asked and answered using the RFI tool in Procore. All RFI's submitted and answered will be viewable by the Skanska project team and all students participating in the sustainability competition.

Supplemental Information:

Some of the problems have additional supplemental information, reference materials, drawings, etc. They can be found in the Documents tool on Procore.

Supplemental Problems:

Supplemental Problems may be provided during the problem statement competition. Supplemental Problems may be additional information about a changing condition that needs to be incorporated into a team's final solution statement. A Supplemental Problem may also be requiring a response and/or solution to accompany the solution statement or may have an earlier deadline during the day. Student teams will need to make note of the conditions and requirements set forth in the individual supplemental problems issued and provide an appropriate response. Note: Supplemental Problems are not 'extra credit' and are accounted for in the total possible points related to their respective category.

Solution Submission Guidelines:

Solutions will be submitted as an attachment to the submittal assigned to your school. All electronic submissions must be in the form of a PDF or other electronic format as stipulated in the problem statement. Other formats may be excepted on a case-by-case basis. Requests for an alternate format should be made before the RFI deadline.

Format of Submission:

In addition to the requirements for electronic submission noted above, the following proposal formats must be adhered to:

1. 11-point Arial font
2. 1-1/4" border around all documents, left justified
3. Maximum submission of 25 pages, including cover page, cover letter, schedules or other documentation necessary to support your submission. All pages submitted will count unless specifically excluded in the written problem statement. All deliverables should be clearly organized and presented. **A two (2) point deduction from the overall team score will be assessed for each page over the page limit described above.**

For submitted drawing markups, charts, graphics, any line/hatching/color codes selected, consider that reviewing parties may have a color vision deficiency (CVD) that would make it difficult to interpret the presented materials.

US Department of Transportation

Request for Proposals

On-Call Sustainable Construction/Consulting Services

February 10, 2022

Background

The Federal Department of Transportation (DOT) is looking to make transportation hubs more sustainable. This includes new construction and renovations projects, focusing mainly on airports and train stations. DOT needs a consultant to assist in cost estimating, focusing on carbon, IAQ, materials and resiliency for their portfolio of projects. Feasibility studies and stakeholder surveys have indicated that these should be top priorities. There will be work above and below ground, in different geographic regions and in cities and, rural areas.

Airports, by nature, face a unique set of indoor air quality concerns because of the surrounding facilities in place. In response to COVID-19, a concerted effort is being made to refocus on cleanliness and system efficiency.

In the modern age with an increased emphasis on energy conservation and efficiency, tight building envelopes have been more important than ever before. While reducing the amount of energy that is transferred from the indoor environment and the outdoor and vice versa these new envelopes now reduce the free flow of air and can even lock in contaminants and pollutants making indoor spaces 100 times more polluted than outdoor ones.

The DOT would like to focus on preparing for and mitigating man-made environmental and natural disasters. As a result of this, resiliency is one of the main categories that will be addressed in this proposal. Resiliency is a vital consideration because of its role in preserving our society.

The discussion in the construction industry around energy efficiency has transitioned into a discussion of carbon emissions. DOT is committed to reducing CO2 emissions operationally and through the construction of new buildings.

Material selection plays a vital role in achieving a project's core objectives. For the purposes of this RFP, this translates to achieving sustainable targets in waste, resiliency, indoor air quality (IAQ), and carbon.

Below are two transportation projects Skanska has completed recently. These are shown as reference projects for responding firms.

Portland International Airport (PDX)

The Portland International Airport (PDX) consists of an 860,000 square foot renovation, expansion of the main terminal and a new 9-acre, long-span roofing system over the entire terminal core complex. The roof structure is supported by 426 concrete piles and 34 Y-shaped steel columns. Special consideration was given to the structure's ability to withstand a major seismic event given the airport's location within the Cascadia subduction zone. The roof

structure is composed of 3.4 million board feet of regionally sourced wood from Oregon and Washington forests. PDX will include new security lanes, local Portland-inspired vendors, and provide passengers with a direct experience with nature via landscape, daylighting, materials and visual and thermal comfort. The PDX project is pursuing LEED Gold certification.



Los Angeles Airport (LAX) RUE (Roadways, Utilities, and Enabling) Project (\$335 million)

This design-build project consists of around 30 separate work packages, covering scopes ranging from intersection improvements to CCTV camera install to utility relocation to signage. RUE is a part of LAMP, Landside Access Modernization Program, which is LAX's initiative to update the airport and increase efficiency.

La Guardia Airport Terminal B Redevelopment

This multi-billion project is part of a new vision for the overall redevelopment of LaGuardia Airport in Queens, New York. When complete, it will improve the traveling experience for millions of people and be a major economic generator for the region. At the forefront of this project is a commitment to sustainability and an approach that minimizes environmental impacts. It is the first project in the world to earn Envision V3 Platinum certification.



Supplementary Information

Supplementary resources can be found in the Documents tool in Procore. This includes any drawings, tables, forms, etc. referenced in this problem statement. Be sure to read the entire RFP carefully and comply with any section of the RFP that requires a submission in a specific format or provided template.

Evaluation Criteria

The list below outlines the evaluation criteria DOT's selection committee will use to evaluate all RFP submissions:

1. Points are listed at the beginning of each section of the response requirements. The maximum points that can be awarded for written responses is 85.
2. There are point deductions for late submissions, submissions over the total page count, or submissions not following format specifications.
3. The selection committee will grade responses to questions asked in interviews Friday. The maximum points that can be awarded for the interview is 25 points.

Format of Submission

In addition to the requirements for electronic submission noted above, the following proposal formats must be adhered to:

1. 11-point Arial font
2. 1-1/4" border around all documents, left justified
3. Maximum submission of 25 pages, including cover page, cover letter, schedules or other documentation necessary to support your submission. All pages submitted will count unless specifically excluded in the written problem statement. All deliverables should be clearly organized and presented. For submitted drawing markups, charts, graphics, any line/hatching/color codes selected, consider that reviewing parties may have a color vision deficiency (CVD) that would make it difficult to interpret the presented materials.

RFP Response Requirements

Introduction

Proposing teams should submit the following qualifications along with their proposal responses.

1. (1 pt) Summarize your company's background. This should be a brief paragraph with no more than 100 words.
2. (2 pts) Organization chart of proposed key personnel and their roles and responsibilities. This counts as 1 page toward your page count and should not contain more than 200 words.
3. (2 pts) Briefly explain your company's expertise. Include any innovative strategies you would bring to DOT projects and specific experience your team has that aligns with the DOT priorities listed in this RFP. This section is limited to 200 words.

Human Resiliency

4. (1 pt) Similar to environmental resiliency, "human resiliency" focuses on the maintenance of healthy habits. Now more than ever, health is of utmost importance. The owner wants to make sure the proposal team holds "human resiliency" as a priority well, because a successful proposal is not possible without a healthy thriving team.

Create a 5min toolbox talk to present your plan to maintain resiliency among team members during competition. Create 1-2 presentation slides and upload as a submittal to Procore by 10am. Choose to present on either mental OR physical health.

Send 1-2 team members to present at assigned time slots.

10-10:10am – Brigham Young University

10:10-10:20am – Cal Poly SLO

10:20-10:30am – CSU Pueblo

10:30-10:40am – Santa Clara University

10:40-10:50am – UC Berkeley

10:50-11am – UCLA

11:10-11:20am – University of Florida

5. (3pts) (Carbon, IAQ) The Department of Transportation understands that carbon emissions affect air quality. The Federal DOT is researching ways to improve air quality in train tunnels and underground stations.
- From the provided study, what are the PM2.5 levels in New York and Boston underground and on the train?
 - Can you find any data for PM2.5 levels in San Francisco train stations?
 - Per WELL guidelines, what is the maximum acceptable level of PM2.5 for indoor air quality?
 - What strategies or technologies does your firm have experience with that the DOT could implement on projects?
 - Resources:
 - Include the study we found with air test results
 - WELL Feature 1 limits PM2.5 levels for IAQ at 15ug/m3 - can they find this online?
 - <https://www.airnow.gov/>
6. 3pts (Carbon) What strategies would you recommend we implement on projects to reduce carbon emissions during construction? Give at least 3 strategies. For each strategy you list, provide:
- Cost implications
 - Anticipated reduction of carbon emissions
 - Schedule impacts
 - Limitations, such as geographical
7. 6 pts (Carbon) The Federal DOT would like to track carbon emissions during construction. It will be part of the services rendered by the successful sustainability consultant to manage this program.
- First, what is your understanding of scope 1, 2 and 3 carbon emissions? Give examples of each for a construction project.
 - You will be required to track all carbon emissions during construction on each project. You will be asked to create a tracking program and implement it. Provide an example of the reporting format you would use to update us each month on the emissions generated.
 - The report should include at a minimum:
 - Material transport
 - Temporary utilities
 - Construction equipment
 - Waste hauling transport
 - Worker commutes
 - Other (Optional; feel free to add other categories if you feel they are missing)
 - The report should include a summary section which shows emission subtotals for each category listed in part c and the total emissions to date.
 - The report should show a breakout of emissions per subcontractor
8. 3 pts (Carbon, Materials, Resiliency) Embodied Carbon
- A requirement of this RFP is to attend the introductory presentation on the EC3 tool. This is scheduled for Thursday, 2/10/22 at 11:30 am in Southern Pacific EF.

- b. How does the embodied carbon in steel beams compare to that in cross-laminated timber beams? Using the EC3 tool, what is the achievable target of embodied carbon emissions for both materials? Calculate this target using products found in North America. Search hot-rolled structural steel and be sure to filter cross-laminated under mass timber materials.
 - c. Our structural engineer has a requirement for all mass timber to have less than 12% moisture content. Does this affect the material's embodied carbon? If so, how?
 - d. Work with the Resiliency team to discuss the 3 materials fire-rating: CLT, carbon, steel, in terms of their embodied carbon.
- 9. (5 pts) (IAQ) With the stark increase in wildfires during the midst of the pandemic, the DOT leadership has expressed concerns about being able to combat these harmful air particles. An increased emphasis on patron health and safety has been at the forefront of their leadership's concerns and are seeking to add an air purifier system to the terminals. Please utilize the specifications and matrix in Procore to select and justify the most effective HEPA system to be included in the newly constructed terminals. DOT has been able to narrow down their selection to either a large industrial system or possibly utilizing multiple smaller units placed strategically throughout the terminals. Use the uploaded documentation in Procore and provide a formal written recommendation (500 words or less) on what option your team deems to be the most beneficial. Some areas to consider include:
 - a. Energy efficiency
 - b. Cost benefit analysis
 - c. Noise and patron disruption
 - d. Aesthetics and appearance
- 10. (10pts) (IAQ) The Department of Transportation has been presented with a set of phased floor plans that were developed by a client. These areas are to receive structural slab upgrades and make room for future uses by eliminating existing offices and storage rooms. The client is seeking guidance from the DOT, who is requesting assistance as part of this RFP. Using these floor plans (located under Documents in Procore), develop a closure and logistics plan that can be used as a guide for developing future transportation hubs. Within this plan, include the following, keeping in mind that this area needs to remain operational and open to the public to satisfy the client's needs (note this will only count as 1 page toward your overall page count):
 - Walkway for passengers starting from the International Arrivals Bus Canopy to the lobby (4040).
 - Construction should be phased in a way that caters to the owner's priorities as best as possible. The following are areas that are important to the client:
 - Baggage claim devices are critical to the operation of the airport. Show how the closure duration for the baggage claim device will be minimized.
 - Accessibility to restrooms is necessary for the passengers. The public restrooms in the construction area need to be opened as soon as possible. Show how the construction team will accommodate public needs.

- Determine which air quality mitigation tools will be implemented and indicate where they will be located on the phasing plan. Include the following:
 - Supply Air: Ventilation devices & their air supply to the public-facing spaces (think about your data and results from Question 5)
 - Thermal Comfort: Temperature control locations for the supply air
 - Air quality monitoring: Data collection system to assess the ambient air quality/VOC content during construction
 - Demolition containment and dust mitigation: Filtration as needed to prevent construction debris/dust from entering public spaces
 - Natural ventilation: Indicate any opportunities to bring fresh air into the space
- A clear labeling schematic on each page showing areas that are open/closed, temporary/permanent, etc.

b. Propose a mitigation plan describing the following in no more than 750 words. Consider the LEED IAQ resources found in Procore.

- Systems selected and the decision-making process behind their inclusion
- Maintenance plans for temporary equipment
- Air quality measurements & inspections as needed

11. (5 pts) (IAQ) Much of construction is done outside, where air quality is determined by the geographical location of the project, weather, season, climate, etc. At existing transportation hubs, planes, trains, and vehicles contribute to the overall air quality. Combine this with the daily activities of the project's construction (demolition, roofing, welding, etc.) and the air quality of the outdoor construction areas can be compromised.

- a. The safety and well-being of workers (construction, maintenance, or operations) is the top priority for the DOT. The DOT is looking for ways to reduce exposure to jet fuel fumes, train exhaust, and vehicle exhaust for construction teams and their maintenance and operations teams while working outdoors. Identify ways this can be achieved. While HVAC systems do their best to eliminate these fumes/exhausts coming into the building, the size and location of some spaces may still experience some exposure. Identify ways these fumes/exhausts can be reduced or eliminated from indoor spaces such as offices, restrooms, lounges/lobbies, etc. (think about your answer to question 9 & 10).
- b. The incorporation of indoor vegetation can help mitigate/offset the indoor air quality due to planes, trains, and vehicles. Create a table to determine what types of plants would be best in an indoor environment and increase the quality of indoor air. Consider how this would differ in different parts of the country. Also think about the maintenance of these plants. Include the following in your table: type of plant (3-5 species), location/environment it would be best suited for, and maintenance strategies.

12. (12 pts) (Materials, IAQ) Waste Diversion: The LAX project has a waste diversion requirement of 70% for construction and demolition materials. As the contractor on the job, you need to ensure this requirement is met. What strategies are you going to implement to successfully implement this requirement?
- a. Develop an implementation plan. Please consider the following:
 - i. What materials are you targeting for diversion?
 - ii. How might your plan change throughout the construction timeline?
 - iii. How will you ensure that subcontractors are meeting this requirement? What steps will you take if they aren't meeting the requirements during construction?
 - iv. Create a site plan showing the locations of your dumpsters throughout the different phases of the project.
 - b. LGA and PDX would like to mimic the LAX Project's 70% waste diversion requirement.
 - i. What elements of your plan would change based on the two airport projects? Are there different materials you would focus on for each?
 - ii. Along with your PDX Air Quality team, compile a list of construction and demo materials most impactful to the existing facilities. Collaborate with them to mitigate the impact of the construction materials on air quality. For each material identified, develop one mitigation strategy.
13. (5 pts) (Materials, Carbon, Resiliency) Whole Trees vs. Steel Columns: The three airport projects are considering partnering with [WholeTrees Structures](#) to implement whole tree wood columns on the projects in lieu of structural steel columns at select locations on each project.
- a. Perform a Cost-Benefit Analysis between steel columns and whole tree columns. Items to include in your analysis should be (at a minimum):
 - iii. Sourcing limitations
 - iv. Material considerations
 - v. Embodied Carbon considerations
 - vi. One consideration of your choosing
 - b. Based on your cost-benefit analysis, can you recommend specific locations for the whole tree columns at PDX?
 - vii. Sourcing limitations
 - viii. Material considerations
 - ix. Embodied Carbon considerations
 - x. One consideration of your choosing
14. (3 pts) (Materials, IAQ) Material Selection: Please specify and describe the benefits of 1 sustainable interior finish product for carpet, paint, and acoustic ceiling tile (3 total) that would increase passenger well-being and comfort and contribute to the overall reduction of VOCs.

15. (4 pts) (Resiliency) The owner would like Skanska to do a deep dive into the resiliency of their project based on the following city's climates – Portland, Houston, and Tampa. These three cities were chosen to maximize climate and geographical variety across the US. Out of the three regions listed, Portland is most prone to seismic events. Because of this, the client has asked for a seismic analysis of the displacement of the new roof at the Portland International Airport Project. The roof consists of 20 different modules, which are connected to create one unified roof (reference A0.361-D to see an example of the roof modules). Each module weighs about 1,000,000 pounds. The roof has been designed to withstand up to 22 inches of displacement in any direction. The client has provided earthquake ground motion data based on an earthquake duration of 30 seconds. Follow the steps below using the provided Excel template (*Resiliency Attachment A – Seismic Analysis Template*) to complete the analysis.
- Calculate the mass of the roof in kip-s²/in and enter the value into the appropriate cell on the analysis spreadsheet. Once entered, the graph on the right will automatically populate with data. (Hint: You will need to convert the provided weight in lb-force to lb-mass).
 - Using the generated graph, what was the initial displacement of the roof at the start of the earthquake?
 - Using the generated graph, what was the maximum displacement of the roof during the duration of the earthquake? (Hint: Make sure you check the displacement in both directions.)
 - Would the roof withstand the earthquake if the maximum designed displacement is 24 inches?



Rendering of the Portland International Airport project)

16. (3 pts) (Resiliency) The owner would like the airport to have a curtain wall system that will have views of the surrounding landscapes, allow for natural light to brighten the space, reduce energy loads, and improve psychological and physiological well-being. However, they are concerned with the resiliency of a curtain wall system during significant weather events like earthquakes, tornadoes, hurricanes, and volcanic eruptions.
- Using the chart below, provide suggestions/strategies on how the design team can mitigate curtain wall failure during a seismic event, tornado, volcanic eruptions, and hurricanes. Please reference A3.508-D & A3.507-D for an

example of a curtain wall system from PDX TCORE. Do not use the same failure/hazard or design strategy more than two times.

WEATHER EVENT	POTENTIAL FAILURE AND/OR HAZARD	DESIGN STRATEGIES
EARTHQUAKE		
EARTHQUAKE		
TORNADO		
TORNADO		
HURRICANE		
HURRICANE		
VOLCANIC ERUPTIONS		
VOLCANIC ERUPTIONS		

- b. Using the map (*Resiliency Attachment B – US Map*) saved in the Supplemental Information folder please provide the design team with a color-coded markup that shows regions that are prone to seismic events, tornados, volcanic eruptions, and hurricanes.
17. (4 pts) (Resiliency) Flooding is another risk the owner would like addressed in the airport design. As the three selected regions (Portland, Houston, and Tampa) are prone to heavy rain and hurricanes, the design will need to incorporate effective drainage.
 - a. See the map (*Resiliency Attachment C – Template Airport Plan*) in Supplemental Information for a template airport plan. The property boundary is marked in red. Find the area of the property within the boundary. Using your calculated area, calculate the estimated gallons of rainfall within the property limits for each of the following two circumstances.
 - i. Portland assuming a 100-year flood
 1. Specifically, 7.12in of rainfall throughout two weeks
 2. This data is based off the Flood of 1996 statistics. Read more [here](#).
 - ii. Houston assuming a Category 4 hurricane
 1. Specifically, 60.58in of rainfall throughout four days
 2. This data is based off Hurricane Harvey in 2017. Read more [here](#).
 - b. Using your rainfall estimate, determine if the volume is manageable and worthwhile to repurpose per circumstance. If so, provide two alternative uses for collected rainwater that apply to all three regions. If not, explain your reasoning.
 - c. Markup the template airport plan to indicate direction of water flow. Propose location and quantity of drainage features that can alleviate water management in the event of a deluge. Provide a brief narrative to explain your reasoning.

18. (3 pts) (Resiliency) DOT is required to implement the general considerations below into each airport design, regardless of region and climate type. The feasibility studies and stakeholder surveys identified these considerations as crucial aspects of airport maintenance, operation, and safety, and wants to ensure that each airport includes these necessities. Consider the impact of vandalism, like graffiti, on building interiors. Vandalism can decrease property value, lead to significant repair costs, and delay construction projects. It is important to consider mitigation of vandalism as a project need.

- a. Discuss at least two different building components that are likely to be targeted by vandalism, as well as three mitigation efforts or techniques to prevent or reduce the occurrence of vandalism.

Building Component	Mitigation Strategy #1	Mitigation Strategy #2	Mitigation Strategy #3

- b. The owner would like to incorporate initiatives from the Living Building Challenge 4.0 Certification when choosing products for the project, more specifically, reduce the use of Red List products (see *Attachment D – Living Building Challenge*). Find three brands of anti-graffiti products and compare the VOC level and cost of each one. After completing your analysis, create a product data submittal in Procore for the brand that you would recommend and include a paragraph describing the other anti-graffiti products you found.

19. (5pts) (Resiliency, Materials, Carbon) The most impactful US wildfires have occurred in the past 4 years, accounting for 62% of the total structures lost in the past 15 years ([Headwater Economics](#)). In fire-prone areas, it is vital to analyze the strength of structures when affected by regional wildfires. The owner has asked you to evaluate cost and resiliency of Cross-Laminated Timber (CLT), concrete, and steel.

- a. Perform a cost analysis of building cost per square foot for the three materials listed below. Consider both labor and material costs for each material. Additionally, provide comments on the overall resiliency of each material, as well as resiliency when exposed to fire.

MATERIAL	COST ITEM	COST/SF	OVERALL RESILIENCY	WILDFIRE RESILIENCY
CLT	Labor			
	Materials			
Concrete	Labor			
	Materials			
Steel	Labor			
	Materials			

- b. Which of the three materials would you recommend using to ensure resiliency and cost-effectiveness of the structure? Explain your decision using the cost analysis and comments that you completed above.
- c. Perform a life cycle assessment (LCA) on the chosen material using the table below. Be sure to include details pertaining to each of the five main steps, and inputs and outputs.

MATERIAL	STAGE	DETAILS	INPUTS	OUTPUTS
MATERIAL YOU THINK IS MOST EFFECTIVE	Raw Material Extraction			
	Manufacturing			
	Distribution / Transportation			
	Use			
	Disposal / End of Life			