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REFLECTIVE ESSAY

Structures is scary! As soon as freshman year you hear about the terrifying stories of structures class. I heard it was page long problems to solve one little thing and then you plug that one little think into a two page problem to get another little thing. I took duel credit physics at Lee College back at home my senior year of high school. I was the youngest student in that class by 5 years. I loved it! We would fill up 4 white boards to answer one question and I actually enjoyed it so when people told me that was how homework for structures was I was actually comfortable. The math on the other hand was my problem. My calculus teacher always joked on me for my "bad luck" he said I was one of the smartest students he had but one of the dumbest at the same time. I would make the dumbest mistakes on test and quizzes such as forgetting a negative or misplacing the decimal point. I was always making 99 or 97s and when it came down to the AP test to get college credit I was 1 point away from getting a 4. Just my luck. Regardless I felt pretty comfortable with the physics and math but the workload was not normal for me anymore.

My structural understanding of buildings had not yet developed and even though I wanted to learn, I was afraid to. I figured that most structural engineers would take care of the calculations and I would only ever have to focus on design. At least that is what I was always told. Even some Structural Engineering major friends of mine told me that they are told that architects just come up with crazy designs and that it is their jobs to make it happen. With this class and studio I realized that structure influences design and design influences the structure making the two go hand in hand. This realization made me quickly understand that I needed to learn to make the calculations myself in order to validate my designs. The importance of structures is that without the bones of the building, it would not exist. Structure allows our designs to come to life and helps create the many different types of architecture we see today. The most famous and well known architecture has either the most complicated structure or the most visible structure. I was baffled at the number of concepts we covered, but was able to understand the basics on how each topic related to the next. Although there was a ton of homework and quizzes and I didn't like the thought of the amount of workload, I wouldn't have learned as much without that much work.

Concepts

To get our brains in the structural mode, we went back to the basics and discussed the minimum requirements needed for structures to resist forces, stay in equilibrium, and how the vertical and horizontal elements of structure handle these actions. Without the structural stability of these members, the structure would be at risk of failure because it would be unable to resist the forces that cause instability or distortions. In the design process, the first order of business should be to determine a preliminary structural type and organization, then move to evaluating structural strategies, and then a final conduction of analysis and design of the structural elements is performed to come to a final outcome. This process was demonstrated in the first homework assignment where charts were used to select structural systems and begin basic calculations on sizing of structural elements.

The next set of topics included in Note Sets 3.1 and 3.2 addressed forces, vectors, and moments. These ideas that make up structural math are all derived from physics and gives meaning and relation to the measurements. Assignment two consisted of creating free body diagrams to use toward finding resultant forces along with their angle and how this affects the size and direction of a force. In addition to resultant forces, we learned how to calculate vectors which included the parallelogram method as well as the tip-to-tail method. The introduction of moments was more familiar to me because it was very similar to what I did in physics. Moments are influenced by magnitude and direction and have the tendency to make a body rotate about an axis. The moments we used in class were similar but different but I was able to catch on eventually.

In applying the knowledge gained from the forces section, we were able to move on and calculate equilibrium of a point and could relate that to analyzing planar trusses. In order for a truss to be stable, its geometry must create equilibrium at all points so it can withstand the load placed on it. This lesson was probably the hardest for me because it was not just numbers and calculations. It now became the beginning of being able to relate it to my projects. I had a hard time visualizing these concepts. The second assignment also demonstrated joint configurations that make up truss systems and allowed us to become familiar with the different types of "special cases" that would make solving for the forces in a truss much simpler. These special cases were pretty easy to grasp and helped out a lot. We were also able to actually calculate the forces in each arm using the method of joints which prepared us to move on to the method of sections, In finding the individual forces, I learned that a positive force meant a truss member was in tension while a negative force meant it was in compression. That concept was applied in later assignments and allowed me to understand how each member would react under a load in an actual structure. By using the program Multiframe, we were better able to understand what our calculations were telling us because the program produced a visual image of the forces in a truss system.

Truss systems also included the discussion of rigid bodies being coplanar force systems that don't deform. Rigid bodies require proper free body diagrams in order to determine what is in equilibrium as stated in note set 5.1. The reaction on a rigid body is determined by the connection or support type. The type of connection also aids in determining the force of a member and moment whether it be a pinned or fixed connection. I am still a little confused about exactly what it means to be pinned or fixed. I understand how to figure out what it needs to be and I understand the difference but I am still having a hard time picturing it. Studying the truss systems led to the second method of solving for member forces known as the method of sections. I was very confused about this concept when we first discussed it in class and only somewhat began understanding it after studying for quiz 2. The method of sections helps when you only need to solve for one or two forces, but it became confusing for me when after cutting the section you have to pick a point to solve for. This method allows you to determine the support reaction and use that as an equation in order to find out other member forces, Note sets 6.1 and 6,2 discuss the mechanics of materials and how materials endure stress and strain based on how elastic they are and how they also undergo thermal effects. Materials have an allowable stress and are also under the influence of normal, shear, bearing, bending, and torsional stresses. The note set associated shear and bearing stress with bolt and bolt plates.

The example of the bolt plate connections helped me understand that shear stress acts perpendicular to a length of a member or parallel to the cross section. The most used equation and one that many say is only one of the two equations you need to take from structures is f=P/A where P is the force and A is an area. The effect of thermal properties such as a temperature change on a system can cause a strain within the material and causes an internal stress that can negatively affect the system. This made a lot of sense to me because I learned about it my materials and methods class I took sophomore year. Strain can also come from shear or axial loads on an object and can cause elongation. Beam shear and bending was most understandable to me with the use of the semi-graphical method. Assignment four was probably the assignment I felt most confident in and actually understood everything I was doing. This part of structures clicked for me so I actually enjoyed doing the problems. The semi-graphical method helped me understand the relationship between the shear and bending moment diagrams in that area of the loading gives a change in shear and area of the shear gives a change in bending moment. The shear and bending moments occur over the length of the beam and were used to find the maximums for design.

After understanding how a beam reacts with forces placed on it by solving for shear and bending moment diagrams, we moved on to observing cross sections. The cross section shape is important to understand because it explains how a beam or column's behavior will resist bending and twisting. By defining terms such as centroid being the area center and moment of inertia being the area "spun" around squared, we were able to understand key concepts required to find beam bending and shear stresses. Having to create charts for each shape helped me understand how to get to the answer, but I didn't fully understand how to apply this concept until quiz 3. I was able to read the charts and record the proper information, but it took me a long time to understand that if a shape differed from the way it was presented on the chart, then some of the values would flip. That was one of my biggest mistakes I made on that quiz.

From cross sections, we moved on to discussing structural frames that could be pinned or rigid. This involved drawing a more detailed free body diagram compared to the previous ones we had been working on. Drawing the free body diagrams also led to drawing more shear and bending moment diagrams. Assignment 6 allowed us to analyze a compound beam joined with a pin which we were able to determine acts similarly to a simple beam. Setting up the free body diagrams included creating a FBD for each section or part of the beam, making sure to account for the forces at the connection points which are equal and opposite. By splitting the pinned and rigid framed into their basic components, the free body diagrams became simple to make and understand. Shear and bending moment diagrams also took on a new form because you could determine the deflected shape from the (+/-) in the moment diagram. The one place where you had to carefully draw the free body diagram was at the load on a comer frame because that would only be applied to one free body diagram.

In moving away from shear and bending moment diagrams, we started to learn about rigid frames and the other forces that act on it, compression and buckling. Buckling was considered the "impending doom" of rigid bodies such as columns. Solving for buckling required finding slenderness ratios which are the effective length divided by the width of the column on that axis. To find the critical buckling load, we had to determine which axis was weak and which axis was strong and use those to decide which axis governed. The larger of the two after solving Le/r for x and y was the governing measurement. The critical load would then be determined from this larger slenderness ratio. It was sometimes difficult to decide which axis was strong and which was weak, but I eventually figured it out thanks to quiz 4. Using the buckling shape chart also helped with determining certain values which we would readdress later in other note sets. We then moved on to design loads which include dead and live loads along with other load factors that are given letters to identify them by type. The concept of dead load and live loads was familiar because of the materials and methods class. The use of those load types led to learning about ASD and LRFD design (Allowable Stress Design and Load and Resistance Factor Design) in note set 13.1. ASD design is used for maximum stresses compared to allowable stress while LRFD loads have been factored and are used to evaluate for maximum loads, moments, or stresses. Using ASD and LRFD helped in determining design because they relate to building codes that must be followed. The structural system would not only have to pass ASD or LRFD calculations to prove the design is stable, but would also have to satisfy the building codes for that material.

Load tracing was a concept that I thought would be simple because I understood that the structure had to carry the weight of the loads all the way to the ground. Always remembering to use the correct constant for the load type was a little confusing especially since they vary from ASD to LRFD but the flow charts really helped. In order to trace loads, you have to be able to understand that the horizontal members in a structure must transfer the weight of the load to the columns to get the weight to the ground. We had to solve for the tributary width which is the area from the center of two beams to the center of the next to find the tributary loads on horizontal members. We also learned that retaining walls have to be designed to resist overturning, settlement, sliding, and bearing pressure. On assignment 7, we were able to apply these new terms and math related to them to understand how to find critical toads for ASD and LRFD design as well as how to find resulting forces, pressure, and safety factors of a retaining wall against overturning and sliding. The hardest part of load tracing was making sure to multiply the calculated load by the tributary width to get the total load on the member.

Note Set 15.1 introduced us to wood design and construction. In materials and beam design we learned that strength of the material can vary based on wood type, grain direction, and flaws. Most of what I learned in materials and methods was applied to this lesson. In calculating wood beam design, we again had to make shear and bending moment diagrams and then use Vmax and Mmax to solve for Srequired and Arequired in order to pick a specific beam size to see if it would support the given loads. The process of design is a constant cycle of trial and error, so if the first section picked did not check out with the other values, then we had to try another until we got an answer that would satisfy all of the requirements. For wood beam design, the design had to ensure that stress wasn't exceeded based on ASD design. The column designs couldn't exceed stress or capacity based on slenderness ratios and there had to be enough nails in the connection to withstand loads. Joint connections in wood design could be interlocking, mechanical, or adhesive. Mechanical connections can cause members to have holes which reduce the overall area and increase tension stress. The holes in the material led us to calculate Ae for effective net area.

Steel design varies based on the grade of the steel and has a high strength to weight ratio. Steel beam design's limit state is yielding all across the section. The beam must undergo load and resistance factors and we typically designed steel using LRFD. Steel beams have to have certain strength for their design but must also have serviceability and involve super positioning with the use of beam charts. For a steel beam to have lateral stability it requires bracing and to lessen buckling the beam would need to be stiffened or have a larger Iy. Steel trusses also require literal bracing and the design must consider buckling. Steel column design involved solving for Kl/r to find an appropriate Fcr to then compute P~~allowable~~. Once you check the design efficiency and use the column charts, you could determine if the picked section will work for the given values. Steel connections are needed to support beams, connect truss members, and splice beams or columns. The connections are subjected to tension or compression, shear, and bending. Connection types can vary from welds to bolts and provide different strengths to aid the design. Assignment 9 helped me learn and understand how to use the W shapes charts to determine a steel section size. At this point I figured out that a key skill needed in this class was the ability to know what chart to look at and be able to understand the chart.

Our last topic covered was a very important one because it was concrete design. Concrete is used in so many different ways in building construction and design, so knowing how to use concrete and how much is used to be economical was an important lesson. Reinforced concrete design was our major focus because concrete itself is not strong enough to resist many forces, so it requires steel to reinforce it and increase the amount of tension concrete can handle The complexity of solving for reinforced concrete design came when a dimension was missing out of height, depth to the centroid of the steel, and the width of the beam. If all of these measurements were available then the amount of steel reinforcement needed was based on a reinforcement ratio which was fairly simple to calculate. The hardest element to solve for was the effective depth to the centroid of the steel because the value would change any time the height or diameter of the reinforcement bars changed. Concrete reinforcement design also included designing for the shear reinforcement which meant designing the type, number, and spacing of stirrups to provide strength and prevent cracking. Concrete foundations require a certain amount of reinforcement as well because the concrete has to withstand the transfer of loads which we calculated using ASD, but using concrete designed with LRFD. Assignments 8, 9, 10, 11, and 12 allowed us to solve for multiple concrete designs.

At the beginning of this semester, I was terrified of just the thought of structures. I felt confident about the math and physics but was scared once I skimmed through the note sets and saw pages and pages full of symbols I had never seen before. With each new concept we covered I felt overwhelmed and as if I would never figure it out. There were plenty of times where I was confused, but most of it I was eventually able to work the problems out and understand how the concepts were applied. My studio professor Haliberton helped connect the dots when it came to applying what I learned in class to my studio design. He wanted us to make a grid and then add columns, beams, and girders to create a structural system. Looking back now, I am able to appreciate each concept that we learned because it will benefit me in my future studio projects and career. I can now create a design and am able to come up with a simple structure that will support that design so it can actually come to life. Without this class I would never have been able to pick adequate sections or create shear and bending moment diagrams, but now I can do all of that and be successful at my design attempts.

Skills

This course provided me with various skills that were important to my success in the class. One of the major skills learned and applied to multiple concepts was the free body diagram. By using a free body diagram I can determine all of the unknown forces on a member depending on the loads acting on the body and the support types. The process of creating a free body diagram includes making sure the point or object is in equilibrium and then indicating all of the forces acting on that point or object. These additional forces are noted with a magnitude and a direction and any unknown forces are also added to the diagram. Solving for the unknown forces requires the use of dimensions and angles represented in the free body diagram. Since the point or object must be in equilibrium, then the sum of its forces and moments must equal zero.

Another skill I developed throughout the course of the class was reading design charts, tables and diagrams. Being able to read these charts was essential to solving many of our assignment problems because they are required to reference the appropriate data to design a member. The variation between the charts and tables was very confusing and it was difficult to determine which charts were used for what problem to find a certain solution. Without the charts we would not have been able to design appropriate structures. The use of charts dominated assignment 9 and on and ranged from Lateral Load Capacity of Common Wire Nails, to Standard Load Table for Longspan Steel Joists, to Available Strength in Axial Compression in kips of W Shapes. Not only did we have to know how to read the charts, but we also had to know when to use a certain chart or table and how to apply the information gathered in order to design a member. I can just imagine architects and structural engineers with laminated versions of these charts readily accessible to them.

Many of the skills gained from this class involved the design process of a structure. Choosing the correct material for the job required knowing what factors to apply for LRFD load types and how to find the self-weight of beams. Each material varied in some way making choosing the correct material for the beam, column, or connection difficult. Not only did this process require knowing each equation to carry out the steps of each design, but also included knowing how the equation affected the design process. The calculations we made were used to determine if the requirements of each design were met, but if area or sections initially chosen resulted in stresses larger than those allowed, the process had to repeat itself and you would have to choose a new section and check the requirements until all were satisfied. An example of this would be solving for the amount of steel reinforcement necessary for concrete design and knowing if it was too much or not enough. In addition to finding the amount we would also have to check that it fit within the concrete member, if stirrups were needed, and determining the spacing between the bars.

A simple skill that I gained from this class was the relation between objects you are designing. For example, a longer span needs a deeper member. The self-weight could make a member inadequate. There can be multiple options on the chart that will fit in the required amounts but one will be more economical than the other due to certain factors. Although design is trial and error I learned there are ways to skillfully pick what to try first with a better chance of it working.

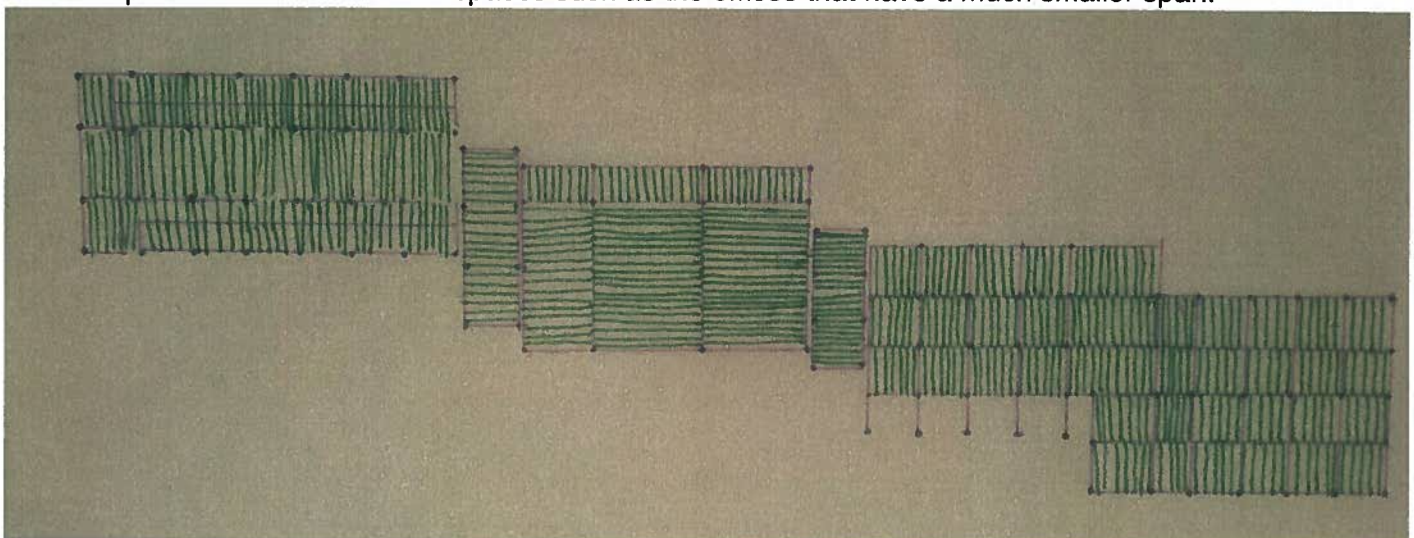
Problem Solving Abilities

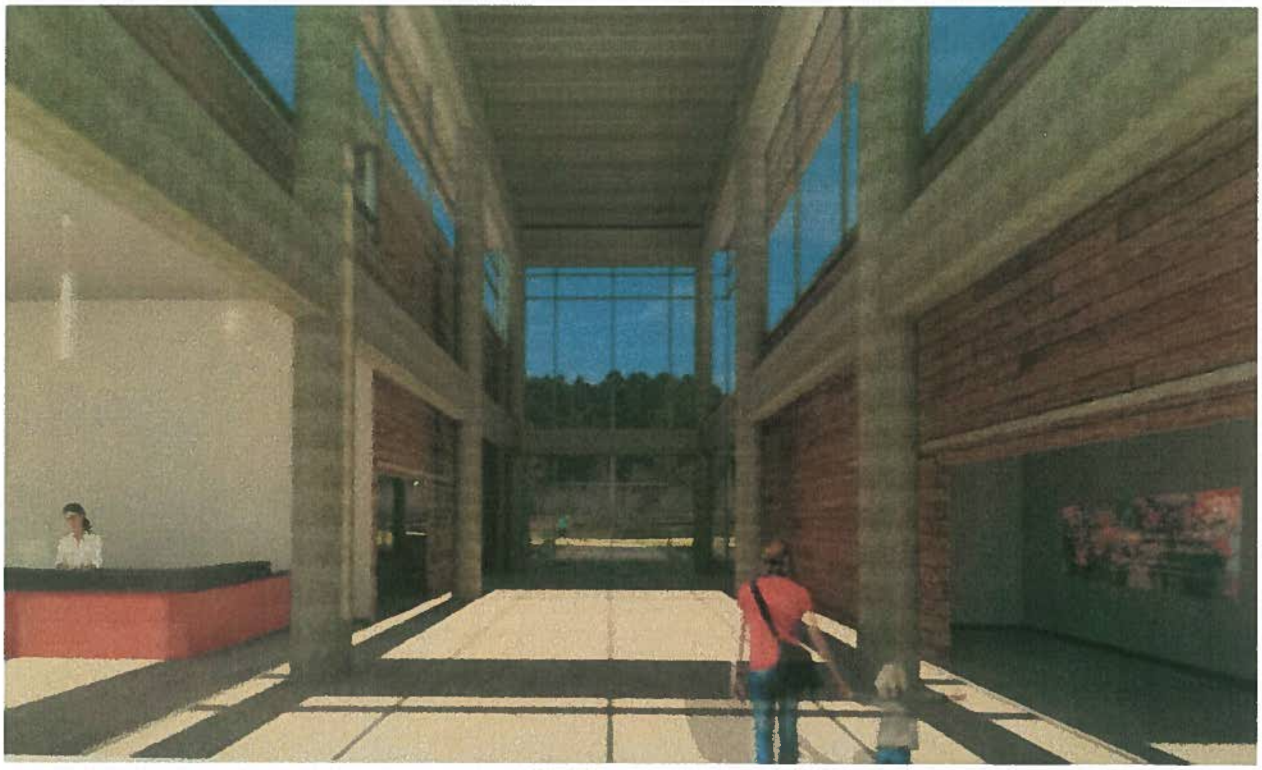
Structures was a different kind of difficult than I was imagining. The difficulty of the math in this class lies in two parts. The first part is breaking down the problem into steps that allow you to understand not only the equations to use, but the concepts behind these equations. Making sure to carefully read the problem and associate an equation with a concept was an integral part of being successful. Also understanding the relation between all the equations and how they fit into each other was confusing at first but was one of the first things I had to learn to do right. The second part is being able to correctly compute the equations with a calculator. So much error can come from simple calculating mistakes that make you want to kick yourself later. The timed quizzed made this a more prone error, but eventually I was able to get the hang of pacing myself and double checking my calculations. I remember on quiz 1 I went through the entire problem before I noticed I forgot to put a parentheses in the calculator in part a. The most important thing to remember when solving any structural problem is to take the problem step by step and always check your work.

Learning Abilities

I truly thought that seeing in class examples would give me the knowledge to do each assignment on my own without difficulty but it was really hard for me to keep up in class. I tried to stay organized and use color pens to separate the steps but no matter what I would always get lost in class. I guess I am just used to going in a slower pace when it comes to learning about a lot of concepts. I normally know why and how before I know what to punch into equations. When I had to turn around and do the assignment problems on my own time, it was really hard just doing the homework alone. The only way I was able to learn was by practicing the problems and the steps it took to get to the solution. When doing an assignment, I would have to read the problem and then reference an in class example and continue to go back and forth between the two until I could solve the problem. I never felt the need to visit the help desk because so many of my peers were also in the class and someone was always bound to have an answer to my question. Working as a group on the assignments helped each of us learn because if one person had a question, whoever could answer the question was in turn learning by teaching, I found this technique effective and I believe others in the group did as well.
The assignments were more time consuming than I had anticipated even with the warnings of past students who took the course. I would always put studio first and would often save the assignments until the night before they were due. Monday and Wednesday nights were structure nights. I never did studio past 5 on those days because I wanted to devote all that time to figuring out my homework and studying for quizzes. It also helped that the people I studied with were in my studio. I feel like I could have devoted more time and it is risky to wait until the night before but I feel like I did really good at managing my time. I worked for me. I was able to grow as a learner because I had a routine and it allowed my mind to grasp concepts and apply them to assignments or quizzes in an organized manor.

In studio professor Haliburton ask us to include structure in our design and at first I was scared. I learned how to load trace and how to be able to select sections given self-weight and dead load and live load but it was different when it came to my own project. I was not planning on having to deal with structure until integrated studio. Of course James loves structure. We had a simple geometry so it was easy for us to come up with a grid. Our building is a series of intersecting rectangles. Our grid was more economical because it was squared as well as consistent. For majority of the building we used 26' squared grid and the columns were able to be hidden in the walls. We then created a beam system with Tjoist that end at girders. So the load would go from the beams above the ceiling to the girders in the wall and then out and down the columns that are also in the walls. In our atrium space we exposed our structure showing two levels of girders but only one level of beams. Our structure is just a rough estimate for now just to get the idea. If we were to continue with designing the structure we would have to calculate the exact loads in order to design the correct beams. The one thing we did know for sure was that in spaces that had a larger span such as the gallery spaces we would need to have deeper members than in the spaces such as the offices that have a much smaller span.





CONCLUSION

Although I dreaded this semester I really learned a lot. Studio was tough to handle with structures and systems at the same time. I am glad I was required to take these classes to prepare me for integrated. Taking structures only added to the stress of my semester but it equipped me with the knowledge I will need to advance. I can now be confident in knowing the general way that structure behaves and be able to identify a structural type that will support a certain building design. I'm no engineer but I will be a better architect after this class.