Designing and Building Structures

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***Abstract*— From skyscrapers and buildings to bridges and homes, structures play an important role in our world. The building process of structures starts with defining the goal of the structure, as well as its constraints and requirements. Then, after a long process of brainstorming, creating the design, refining, and repeatedly testing the structure virtually, the building process begins. Through a process like this, civil engineers design and build all the infrastructure that makes up the world we live in today.**

Keywords—civil engineering, design, safety, engineering, physics, structural engineering

I. INTRODUCTION

The engineering design process for structures includes tedious designing, testing, and repeatedly going over the design to ensure its quality, functionality, and safety. In addition to creating a design that meets all the restraints of cost and functionality, civil and structural engineers have a responsibility to the safety of the people using the structures [7], which is why repeated online testing in virtual environments is crucial to provide a safe structure for people to use. Using online simulations and models, or smaller physical models, engineers can simulate their structure, gathering information on its performance according to standards without wasting materials. In addition to meeting standards for everyday use, engineers must be prepared for special cases, such as earthquakes and strong winds, which are very likely to damage a tall building or a bridge. The core of civil and structural engineering is designing structures with functionality and safety for everyone.

Fig. 1: The Burj Khalifa, an incredible product of structural and civil engineers. Source: [1]

II. PURPOSE AND CONSTRAINTS

Defining the purpose of the structure is important early on. After all, how can you start building without having a clear idea of what you're building? Engineers must have a clear visual of what they are building and the goals they want to achieve with this structure [7]. In addition, they must also have a clear idea of the constraints of their design. Constraints include a budget, environmental factors, safety factors, and physical limitations to the structure, whether by the environment, such as soil condition, or how much space is available for the structure [5]. Only when a clear purpose for the structure is defined and constraints are acknowledged can engineers even start to design, create, and eventually build their structure.

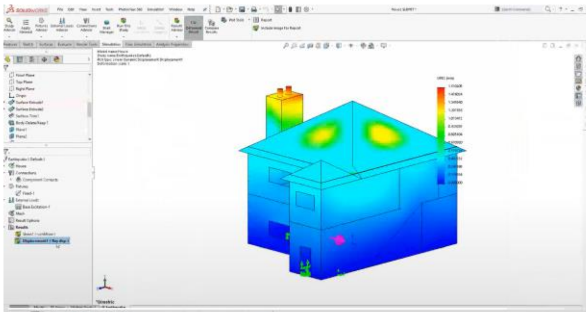

Fig. 2: SolidWorks CAD. This shows an example of earthquake analysis on a house. Engineers can use this information to detect risks. Source: [2]

III. PROTOTYPE AND MODELS

A. Prototype and Plan

After having a clear idea of what to build, engineers can now make a model of what they should build. Starting from concept sketches and brainstorming ideas, engineers eventually make a rough idea of the design, which is then turned into either a small-scale physical model or an online model. This to decide are where to build it, the materials needed to accomplish this task, a minimum budget, the workforce necessary to finish the job, as well as deadlines for different phases of construction [5].

B. *Models*

Models are incredibly important and useful for the civil and structural engineering process. Powerful online tools can help visualize and simulate a finished structure without wasting any materials at all. Incredibly useful information can be derived from that model: information crucial to knowing a design's future success, information that can reveal the flaws of a design. Now, even more powerful simulations can also model real-life physics, providing engineers with a way to test their structure against various factors, whether a traffic jam on a bridge or a building during an earthquake. Then, engineers can address these issues by improving their design, while the online model continues to offer important insight into its flaws. CADs, or computer-aided design, offered by software like SolidWorks, present great tools for viewing the structure and testing its limits [4].

IV. BUILDING THE STRUCTURE

A. Before Construction

Factors to consider before building the structure include selecting the site to build on and analyzing the surrounding geography, land stability, and soil to ensure the structure operates well in these conditions [8]. These are to ensure that where the structure is built is fit for the structure and to prevent many environmental problems that could damage the structure in the future.

B. During Construction

During the building, many different concerns arise as well. Engineers should focus on accounting for problems during the building process, including everything that might go wrong, such as equipment failure, building errors, a deficit in supplies, or any delays to deadlines, such as bad weather [8].

Fig. 4: An accident: engineers must be prepared to face such issues. Source: [6]

V. SYSTEM INTEGRATION

One important aspect of designing a structure is integrating all the systems. Systems could include the electric system, water system, sewage, mechanical parts, etc. It is up to specialized systems engineers working alongside engineers from various fields to integrate all these to form a successful whole [5]. Ultimately, a successful integration contributes to the functioning of the structure: powering a house, streamlining production in a factory, or illuminating a bridge at night.

VI. DIFFERENT STRUCTURES AND THEIR NEEDS

A. Infrastructure

Infrastructure includes roads, highways, and bridges [5]. Because all they do is bear weight, infrastructure needs durability over time, as well as the ability to carry heavy loads. Engineers also have to worry about environmental issues, especially high winds for bridges and earthquakes for roads. The best bridges and roads are the ones that last the longest, against the constant weight they bear and the natural disasters they weather.

B. Residential

Similar to infrastructure, residential buildings, like houses and apartments [5], also need to emphasize durability for the safety of their inhabitants. But engineers should focus on other issues as well: a good residential building also depends on appearance and location as well. People emphasize a house's aesthetic appearance, as well as the convenience of reaching certain other places, such as restaurants, grocery stores, parks, etc., things that aren't as much a concern in infrastructure.

C. Industrial

Industrial buildings include manufacturing plants, storage areas, warehouses, and factories [5]. These have different demands from residential buildings. Aesthetics are no longer a concern, but size and space for storage and manufacturing, as well as more structural durability for heavy machinery and the many operations happening there. There should also be easy access and export, as factories need to both receive supplies as well as deliver products [5]. There should also be climate control, depending on what the building is storing or manufacturing, an example being some wood products require dry conditions.

Fig. 3: A beautiful English cottage (the big bad wolf can blow this house in). Meatpacking factories don't have to look this good, but they do need to be more durable. Source: [3]

VII. CONCLUSION

The designing of structures has many important parts engineers need to consider when building a good structure. Civil and structural engineers should aim to build a structure that is functional, durable, and safe. From apartments and houses to bridges and highways, each structure demands different needs to make it successful. These structures make up most of our world: civil and structural engineers are some of the most important people who contribute to how our world is today.

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