INTRODUCTION TO STRUCTURAL ANALYSIS

An Internship Project Report

Submitted in partial fulfillment of the requirement for the award of the

Degree of Bachelor of Science in Mathematics

Submitted by

T. ANUSUYADEVI

Register no. 18BM7446

Under the guidance of

(Mrs.) B.Pushpa M.Sc., M.Phil., DCA.,

Head and Assistant Professor

Department of Mathematics (Self Finance)

Sri G.V.G Visalakshi College for Women (Autonomous)

(Affiliated to Bharathiyar University, Coimbatore)

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CERTIFICATE

This is to certify that the Internship project work entitled **"INTRODUCTION TO STRUCTURAL ANALYSIS"** is a bonafied record work done by **T.ANUSUYADEVI(18BM7446)** submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Mathematics at Sri G.V.G Visalakshi college for Women (Autonomous), Udumalpet during the academic year 2018-2021.

Signature of the staff-in-charge **Signature of the HOD**

INTRODUCTION:

The Internship training program was organized by skill edge “ICT academy”. This is one of the E-learning content. This includes many knowledge persons. One of the knowledge partner “INTRODUCTION TO STRUCTURAL ANALYSIS” gave this course. Author design academy teaches about the foundation concepts to calculate mean, median, mode, variance standard variation, covariance, correlation and utilize data distributions. This is used to discover how professionals use structural analysis tools to create consistent and high quality construction documentation.

CONSTRUCTION DOCUMENTS:

Construction drawings include demolition construction, power, reflected ceiling, millwork details, and finish schedules. Coded furniture plans are assembled. If the scope includes the procurement of furniture, art and plants, bid specifications are assembled.

Elements of construction:

- ❖ It is used to define the different types of project deliverables.
- ❖ It helps us to know the different parts of a set of construction documents.
- ❖ It enables us to understand the relationship between plans and sections.
- ❖ It is used to understand the importance of the construction documentation.
- ❖ It is used to understand plans, sections and elevations.
- ❖ It helps us to use the Revit project browser to navigate a project.
- ❖ It helps us to understand general notes, schedules and sheets.

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Construction Documents:

Each component of the construction documents can be thought of as a lens which focuses on different sections of a design to communicate different requirements.

- Construction documents are the records that are shared with architects, owners, engineers, and other construction professionals to communicate a design. For example, architects and owners need to see floor plans, elevations, and 3D drawings of the design for approval.
- A construction document set (also called a drawing set or a sheet set) is a compilation of drawings created by each trade for construction purposes. Each sheet contains pertinent information required for the building design.
- The contractor then uses these drawings to determine a guaranteed maximum price (often called GMP or G-max price or lump sum price), obtain necessary permits, and construct the project.
- The use of the BIM software file as part of the contract deliverables produces great opportunities for efficiency, challenges for additional risk and liability, and potential for significant new revenue.

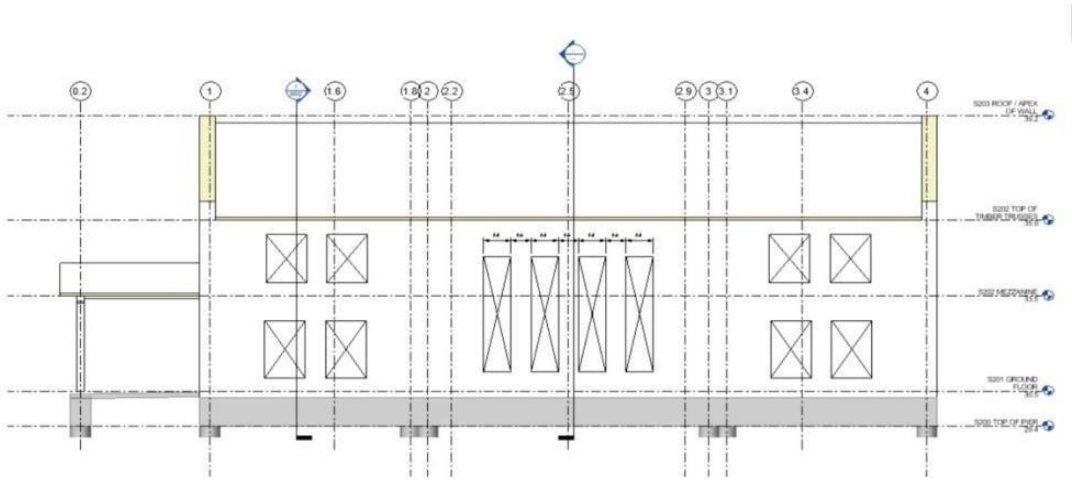
BUILDING PLANS AND ELEVATIONS:

Uses of plans and elevation:

- It is used to understand the components in a plan view.
- It is used to distinguish between the common types of plans foundation, framing and roof plans.
- It is used to understand the importance of structural analysis using elevation in projects.

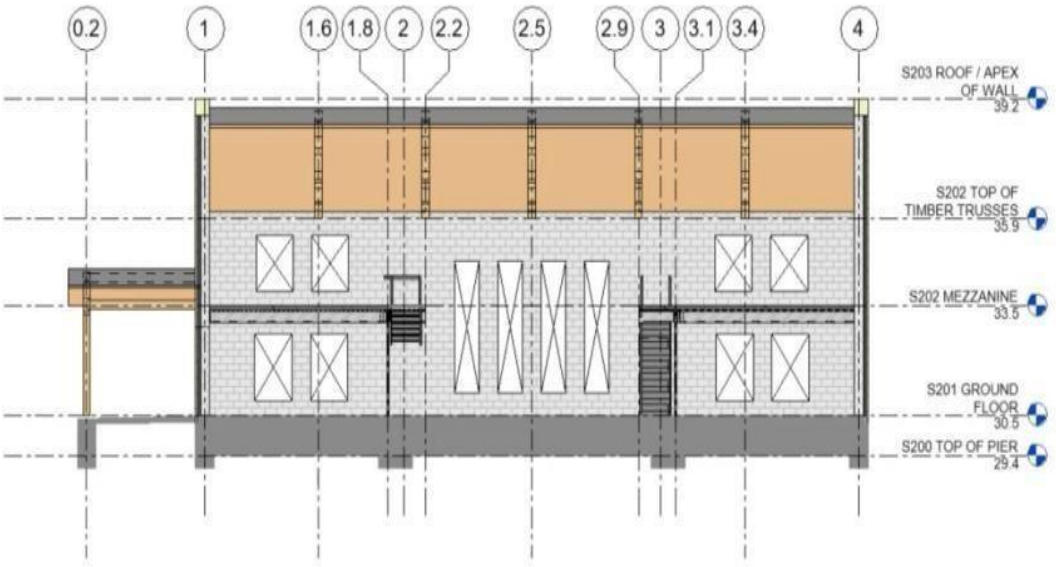
Building plans and elevations:

- Plan views can be thought of as a map of a particular level of the structure with the orientation of the view looking downward from above. In structural engineering, a plan view for a floor uses a view range to isolate a specific floor.
- The view range typically begins at 4 feet above the level and ends at 4 feet below the level. Everything which is cut at the typical 4 feet above the level is displayed in hatching. Pictured is the CMU hatching.
- In technical terms, an elevation is an orthographic projection of a 3D structure from the position of a horizontal plane beside an object. Structural elevations are commonly shown in building plans to allow for the coordination of items, such as structural braces with window openings which are in the building façades of architectural elevations. An example elevation is shown in the figure.
- Elevations are the most common orthographic projection for conveying the geometry of a structure from the exterior. A structural elevation is typically labeled in relation to the compass direction it faces: the direction from which a person views it.



Building sections:

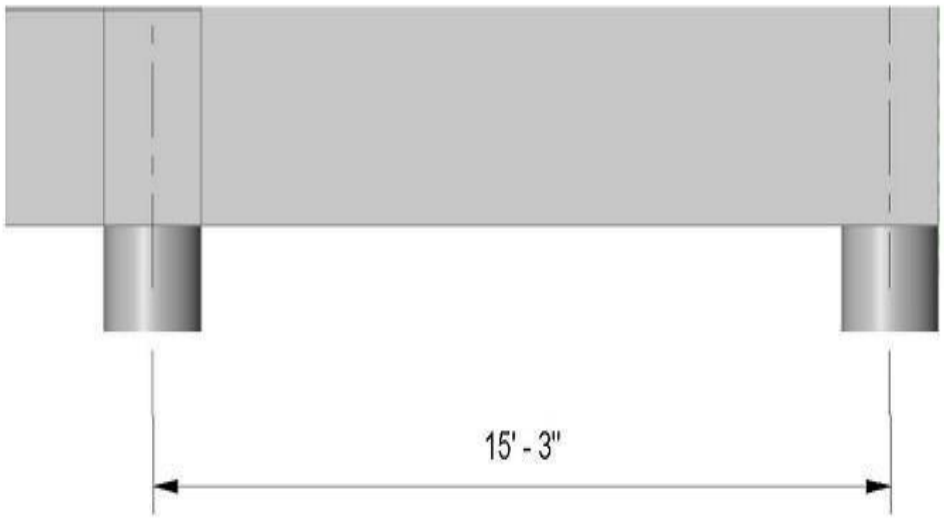
- Section views provide an understandable representation of hidden or complicated parts of 3D models. A section is technically an orthographic projection of a 3D object from the position of a plane through the object.
- The image of the kiwifruit provides a good example of sections. The kiwifruit is cut and rotated until the cut face is shown to the viewer.
- Sections like this show structural features not externally visible, or not clearly visible.
- The style of crosshatching indicates the type of material the section passes through.



- At the degree 39.2 the roof of the wall is to be fixed.
- At the degree 35.9 the top of timber trusses is to be fixed.
- At the degree 33.5, mezzanines are to be fixed.
- At the degree 30.5, the ground floor is to be fixed.
- At the degree 29.4, top of the pier is to be fixed.

Dimensions:

The required sizes of structural features are conveyed through use of dimensions. Distances may be indicated with either of two standardized forms of dimension: linear and angular. A third type of dimension that is commonly used for curved structures are diametrical or radial dimensions. A radically aligned line with arrowhead pointing to the circular feature, called a leader, is used in conjunction with both diametrical and radial dimensions.



Structural design:

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life.

Applications of structural designs:

- Finite Element Analysis and its advantages to modern engineering
- Degrees of freedom and stability in structures
- Design rules of thumb and how to utilize these in sketches
- Dead , live , seismic , and hydrostatic loads and load combinations
- Ability to create graph paper
- Draw structural elements to scale
- Use Robot Structural Analysis Professional to solve a finite element analysis problem.

Overview of the structural design:

- Structural engineering has existed for a long as we have had a need for shelter. Since the first bundle of twigs were tied together to shield against the rain and wind, this field of study has grown in scope and beauty.
- From primitive huts in the rain forests of South America, to the pyramids in Giza, to the Burjkhalifa in Dubai, structural engineering has accomplished staggering achievements.
- In this section, students will be introduced to the basic principles of structural engineering, shown how modern advances in computer technology have affected design, and taught useful skills for building design intuition.

Loades and codes:

- The basic problem of structural engineering revolves around the desire to keep structures in static equilibrium. This means we want everything to remain motionless. If a system is free to move, it becomes a dynamic system and is no longer a static one.
- A structure must be designed to hold its own weight. Weight is a force which causes acceleration.
- If it is not balanced by another force equal and opposite to it, the system will fail. In the field of structural engineering, forces like this are classified as a "load."
- There are several different load type classifications, but the two most basic are live loads and dead loads.

Dead load:

- Dead loads also known as permanent or static loads are those that remain relatively constant over time and comprise.
- For example, the weight of a building's structural elements, such as beams, walls, roofs and structural flooring components.

Live loads:

- A load produced by the use and occupancy of the building or other structure that does not include construction or environmental to loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load.
- For example, the weight of the person, movable partitions, weight of the furniture etc.

Global perspective:

Robot Structural Analysis is a mature program that can run a large variety of design codes. With its international platform, it supports 70 design codes from different countries.

Structural engineering rules of thumb:

- Important Thumb Rules used in construction by Civil Engineers. Thumbs rules play a most crucial role while taking quick decision on site.
- Thumb rules enable you to calculate the solution using a mathematical formula and make smart decisions whenever needed.

Span and depth of structure:

- Roof beam and roof joists: 0.5*length = span (ft) and depth (in)
- Floor beams and floor joists: 0.6*length =span (ft) and depth (in)
- Composite beams: 0.55*length = span (ft) and depth (in)
- Beam depth = ½ inch per foot of span

  (Joists means thickness of ceilings)

Roof system:

A roof system is an assembly of interacting roof components designed to be weatherproof and normally, to insulate a building's top surface. The roof assembly includes the roof deck, vapor retarder and roof insulation (if they occur), and the proof covering.

Aspect Ratios:

- The ratio of building's height divided by its width is known as its aspect ratio. Typical aspect ratios range from four to nine.
- Efficient systems will have ratios less than five.
- The different load resisting systems used in structures is depended on the number of stories included in the building.
- If there is 29 stories or less then it is called rigid frame.
- If there are 30 to 40 stories then it is called Frame - shear truss.
- If there are 41 to 60 stories then it is called Belt truss.
- If there are 61 to 80 stories then it is called framed tube.
- If there are 81 to 100 stories then it is called Truss – tube w/ interior columns.

Stability:

- Even before the creation of the beautiful and complex structural of today, the most important and fundamental concept behind structural engineering has always been stability.
- When a simple shelter needs to be built, even a bundle of sticks propped up to shield against the wind, the preliminary concern lies in keeping the house upright.
- If a structure has the capacity to bear the forces applied to it without tipping over or sliding, then it is stable.

Example:

If a pencil stands upright on its pointed end, it will very quickly fall over. If a hand is place holding the eraser end, it will remain in place.

Complex geometry in structure analysis:

❖ Finite Element Analysis (FEA), or the Finite Element Method (FEM), is a numerical technique for analyzing the stresses and reactions in structures.

❖ Traditional handwritten methods required simple structures in order to make vital assumptions and idealizations such as localizing the mass at its center of gravity or disregarding negligible geometry.

❖ Handwritten approaches would reduce the shape of the beam to a line and consider all the mass to be located in middle. Though these assumptions may help in solving a beginner level statics problem, they prove be inadequate in the analysis of structures with more complex design.

❖ Each element is defined by points or “notes” which have an explicitly calculated and known position. The process of FEA determines mathematical equations to model the movement or “displacement” of each node as a function of x, y and z coordinates.

❖ With the abilities of FEA, the physical reaction of a body may be calculated at any point in the structure. One of the many powers of this method of analysis is the ability to change object material properties.

Basics structure analysis:

Structural analysis is the determination of the effects of loads on physical structure and their components. The result if the analysis is used to verify a structure's fitness for use, often precluding physics tests. Structural analysis is thus a key part of the engineering design of structure.

Overview of sketching for structures:

- For creating sketches using hand calculations are important skills for structural engineering to communicate design and to solve problems.
- This course contains several lessons that show you how to sketch out your design with engineering calculations for a critical
- It help us to understand how sketching prays a fundamental role in structural engineering design.
- Sketch with graph paper as a simple and quick method approach structural engineering problems and challenges.

Sketching To Scale:

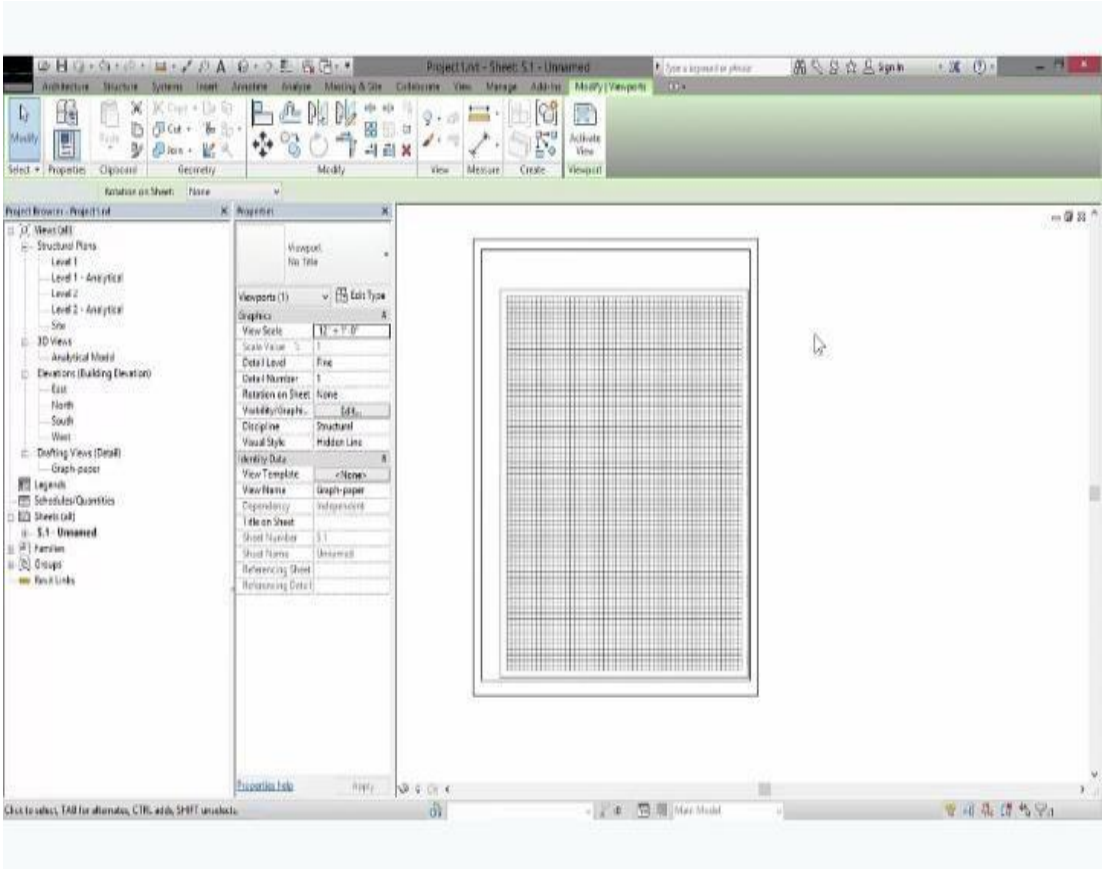
A scale to draw so that all geometry in that group reflects the selected scale. Engineers often create their sketches with a scale that is appropriate for the design project.

Uses of sketching to scale:

- To perform calculation and sketch to scale.
- To sketch frames with different loading conditions.
- To draw rebar with two scale factors to better understanding how different scales can be used to solve problems.

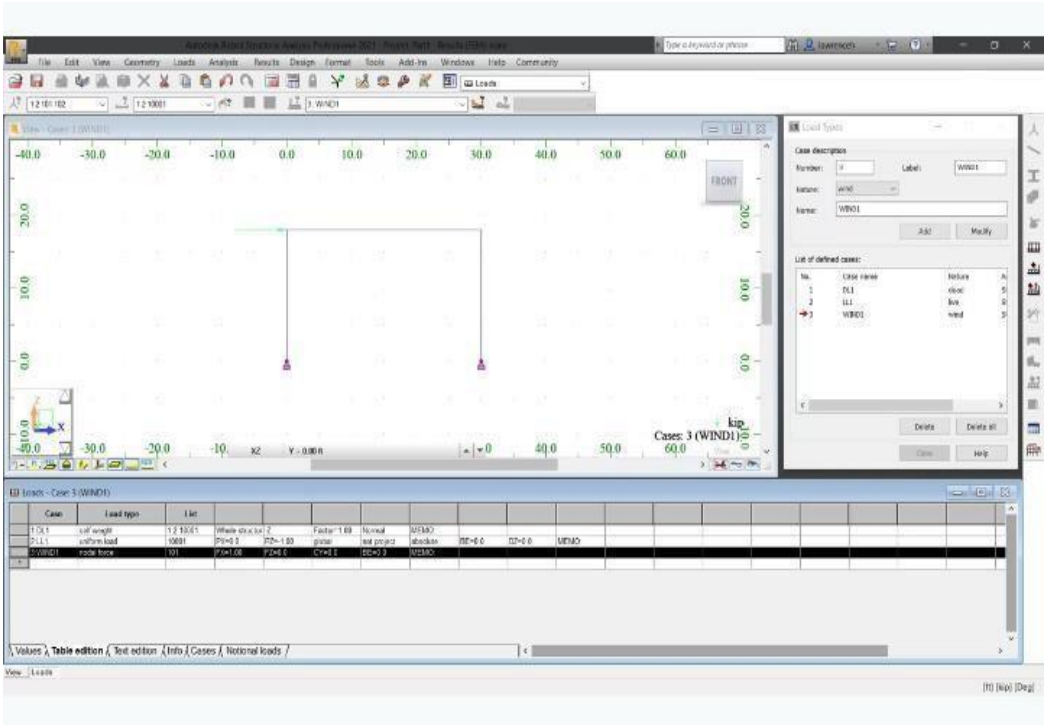
Making Graph Paper:

Create graph paper in Revit for the purpose of sketching with the scale size you prefer (example uses a previous version of Revit but the workflow can be adapted easily to your version).



Structural design of graph paper

- To understand 2D frame design.
- This enables us to create a simple 2D structure.
- It is used to create basic loads.
- It helps to run calculations.
- To understand and verify results.



LATERAL DESIGN OF LOADS

Overview of lateral design of loads:

While dead and snow loads act vertically downward on a structure, another class of loads designates those that act horizontally. These are known as lateral loads, and in this section we will give a brief overview and discuss their historical significance.

Types of loads:

- Wind loads
- Seismic loads
- Modern seismic design
- Investigation of frame stability using Robot structural analysis
- Hand sketching deflection and forces on a steel frame

Lateral Loads:

- Within the study of lateral design several types of lateral loads exist but the most notable are seismic and wind loads.
- Both terms need little description. Wind loads are the lateral forces applied by wind, and seismic loads are the lateral loads that result from earthquakes.

Wind Load:

- Wind load has been recognized long before the academic study of structural engineering. No sooner had man fabricated the first shelter then it was blown over by next storm.
- The basic principle behind a shelter is to protect the inhabitants against the natural elements. It makes sense therefore to design the structure.

Seismic Load:

- If wind load design seems a study of ancient origin, seismic design must therefore be a modern advancement.
- Though seismic failure has affected man as long as any other load type, it is only through recent innovation that engineers are now able to design against it.

Designing reinforced:

- Reinforced concrete as an advanced material.
- The role that reinforced concrete plays in construction.
- Concrete members and their use.
- Concrete, though at first only in primitive form, has existed for millennia. The concept of pourable or formable paste composed of earthy mixtures to fabricate shapes may be seen in the older bit of pottery.
- The cement that glues together stones to form many of dwelling places of ancient man, and the dried mud and straw composing the Egyptian pyramids, demonstrate the antiquity of concrete design.
- Years of experimentation continue to perfect this material concept, and today concrete remains a prevalent and reliable structural total.
- The primary advantage of concrete comes from its pre-handed liquid behavior; no matter what shape or geometry are required, concrete forms exactly to whatever a situation dictates.
- This allows for a wide range of applications. Instead of code dictating which specific steel shape is permissible for a certain condition, the limitations of condition, the concrete, however, is it its poor tensile strength.
- In this section we further detail the material specifics of reinforced concrete and describe its application in structural design.

Concrete:

- Concrete is a blend of bonding material with aggregates.
- Most concrete is formed by mixing aggregates such as gravel and sand into Portland cement paste.
- While the concrete is wet, it behaves plastically, which allows for the concrete to be proud into different forms and shapes.
- When the concrete solidifies through a chemical reaction called hydration, it gains strength rapidly, until reaching its nominal strength at 28 days.

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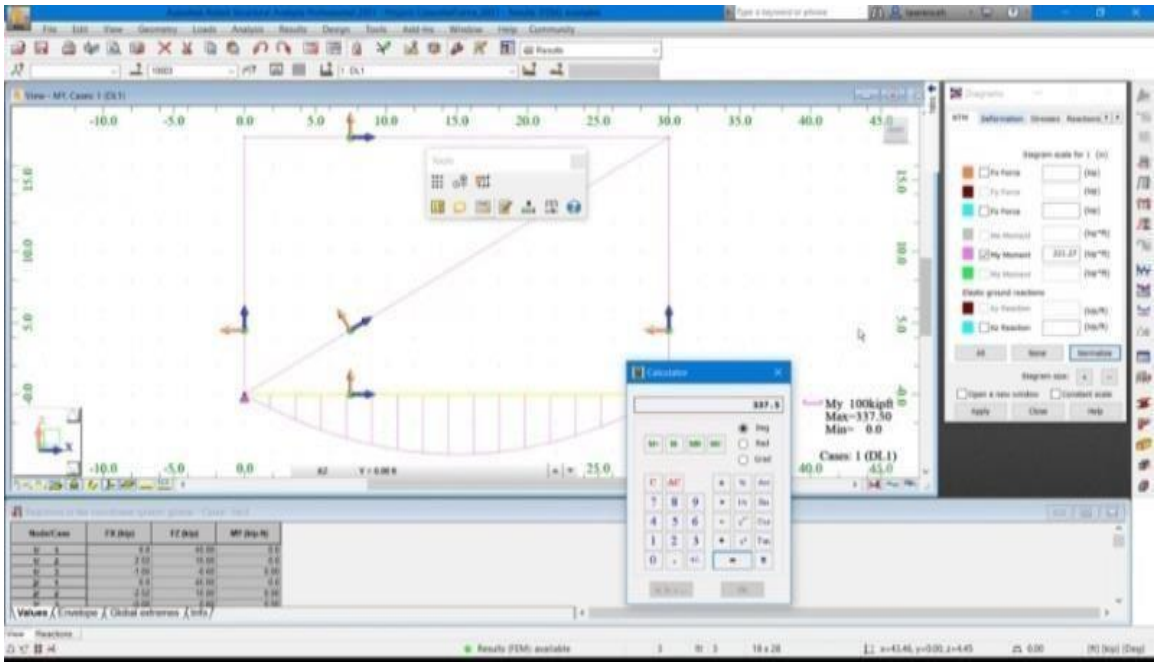
Concrete Design Analysis:

- To understand concrete design on a concrete strap beam, or ground beam.
- It helps to Interpret and validate results in Robot Structural Design Analysis Professional.



Designing structural steel;

- To understand the basic concepts of structural steel and its components
- To describe ASD and LRFD design philosophies.
- It is used for Structural steel design
- It is used for ASD and LRFD design philosophies
- It is used to design rules of thumb and their great importance today
- It is used to design of members, member shapes, column base design

Base Plates:

- Base plate connections are the critical interface between the steel structure and the information. These connections are used in buildings to support gravity loads and function as part of lateral-load-resisting systems.
- It helps to understand and perform calculation for a base plate.

Phased-Based Construction Design:

- Structural steel design seeks to find the optimum structure that will minimize cost, weight, construction time, labor, and cost of manufacturing the components, while maximizing efficiency in operations.
- Structural members must be checked for load bearing stability, or safety. This process includes structural configuration, establishment of loads, member selection, structural analysis, evaluation of safety, and then a re-design of the member if needed.

Uses of phased-based construction design:

- To understand the key aspects of working with structural steel.
- It helps us to explain design rules of thumb.
- To design members, member shapes, and column base plates.

Robot Structural Analysis:

- Robot Structural Analysis is a finite element analysis program that is capable of providing staged analysis through their Phase function found under the Geometry tab. This is a built-in advantage that Robot provides, allowing the engineer to design the transfer girder for its final loading condition while also providing analysis at each phase.
- Robot is set up for the engineer to input different load phases for the element.

CONCLUSION:

This course shows you how to design, analyze, and document your engineering project. You'll utilize the integrated analysis functionality to explore engineering, design, and construction decisions. Lessons on 2D sketching and hand calculations teach you the engineering skills required for solving problems and challenges on structural projects.