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3D MODELLING, DETAILING, ANALYSIS AND DESIGN OF RCC BUILDING USING TEKLA STRUCTURES AND TEKLA STRUCTURAL DESIGNER.

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Abstract.
In the quickly evolving world of today's construction business, software is an absolute necessity to keep up with the pace of infrastructural growth. Verifying the results' computability is the study's primary goal. Our project's main focus is 3D modelling and detailing in Tekla structures, which is currently involved in the development of cement and steel, both counting and casting in-situ as well as precast. These products include improvements, enhancements, and new features to boost productivity and facilitate more seamless workflows. With advancements in the production of drawings, precast concrete, steel casting setup, underlying design plan, and teamwork. It is usually anticipated that the task will be simpler and faster with the latest versions of Tekla structures. Tekla structures were used for configuration, enumeration, and data collection by executives who wanted to create and develop on-site. And also in our project, we use Tekla structural designer for analysis and design. The study and design of Reinforced Concrete structures is the final stage in the construction industry to deliver projects on time and on budget. Analysis and design jobs are not straightforward to complete. Most commonly used software is validated to obtain design outcomes. Beams, columns, and a simple frame are examples of fundamental RC Structure elements. Shear force, deflection, and bending moment of beams and columns are all comparable in the analysis process. Following that, the loads are computed, particularly the dead loads, which are determined by the unit weight of the materials used, and the live loads, which are determined by the IS 875-1987 code.

1. INTRODUCTION:

Tekla Structures is a building information modelling program that can model structures made of various building materials such as steel, concrete, wood, and glass. Tekla allows structural drafters and engineers to use 3D modelling to design a building structure and its components, generate 2D drawings, and access building information. Tekla Structures was once known as Xsteel (X as in X Window System, the Unix GUI's base).

Tekla Structures is utilized in the construction sector for steel and concrete detailing, as well as precast and cast-in-place construction. Users may use the software to develop and maintain 3D structural models in concrete or steel, and it will walk them through the process from concept to construction. The process of creating shop drawings is automated. It is available in a variety of setups and situations. Tekla Structures is noted for its ability to accommodate big models with several concurrent users, but it is also known for being quite expensive, difficult to master, and fully utilize. It competes with AutoCAD, Autodesk Revit, Profiler and Digital Project, Lucas Bridge, PERICad, and others in the BIM market. Tekla Structures complies with the Industry Foundation Classes (IFC).

Within Tekla Structures, modelling scopes include Structural Steel, Cast-in-Place Concrete, Reinforcing Bar, Miscellaneous Steel, and Light Gauge Drywall Framing. In 2004, Xsteel was replaced by Tekla Structures, which brought significantly more capability and interoperability. It is frequently used in conjunction with Autodesk Revit, with structural framing designed in Tekla and exported to Revit in DWG/DXF format.

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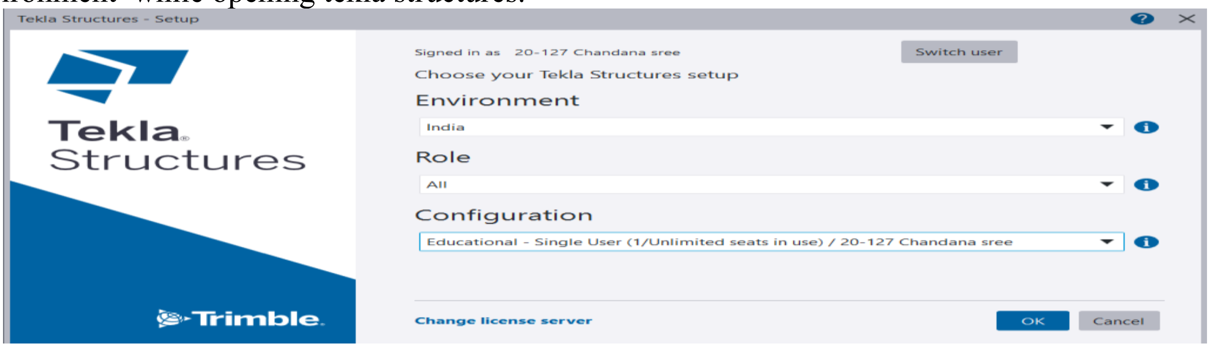
Engineers have utilized Tekla Structures to create models of stadiums, offshore structures, pipe rack structures, plants, industries, residential buildings, bridges, and skyscrapers. Tekla Structures was employed in the design of different construction projects around the world.
Tekla Structures is a structure data displaying programming ready to generate model designs that incorporate a variety of construction materials such as steel, cement, wood, and glass.
This product is used to create and manage 3D main models in cement and steel, as well as to manage the interaction from concept to creation. It competes with AutoCAD, Autodesk Revit, D profiler and advanced project, Lucas Bridge, Priced, and others in the BIM (Building Information Modelling) market. Tekla structures are well-known for their ability to support large models with multiple synchronous clients. This product is widely used in the capital entryway (Abu Dhabi) and UAE steel plans. Tekla received numerous awards for its large and massive projects. One of them is the North American BIM Award for Significant Task.
Tekla Structural Designer is an integrated model-based 3D tool for multi-material structural analysis and design (of both concrete and steel elements).
Interactive modelling, automated structural analysis and design, drawing and report creation are among the features.
There are several design codes supported: ACI/AISC, Euro codes, British Parameters, Indian Parameters, Australian Requirements.

1.1. Objectives:

- To research concept details in the Tekla structures software.
- To assess and explore existing Tekla structure software study material.
- To research and learn the actual detailed technique in Tekla structure program. Using Tekla Structures software to detail a G+2 RCC structure and generate drawings.
- To complete the structure's study and design without any type of failure.
- To comprehend the fundamental principles of the structures through the use of Indian standard codes.
- To comprehend the design parameters for beams, columns, slabs, and other structural components.
- To create 3D models of the structure for extensive study and design using Tekla software.

2. METHODOLOGY:

Tekla Structures is a structure data demonstrating programs ready to exhibit structures that incorporate diverse building elements like as steel, cement, timber, and glass. Tekla enables primary drafters and architects to plan a structure and its components in 3D, make 2D drawings, and access building data. Tekla Structures is used in the construction industry for steel and considerable enumerating, precast and cast in-situ. The solution enables customers to create and manage 3D underlying models in cement or steel, and it guides them through the interaction from concept to manufacture.
Step-1: Initial setup of Standard Codes and Country codes.
Setting up of codes according to our project needs .The codes will be setup by selecting an environment while opening tekla structures.



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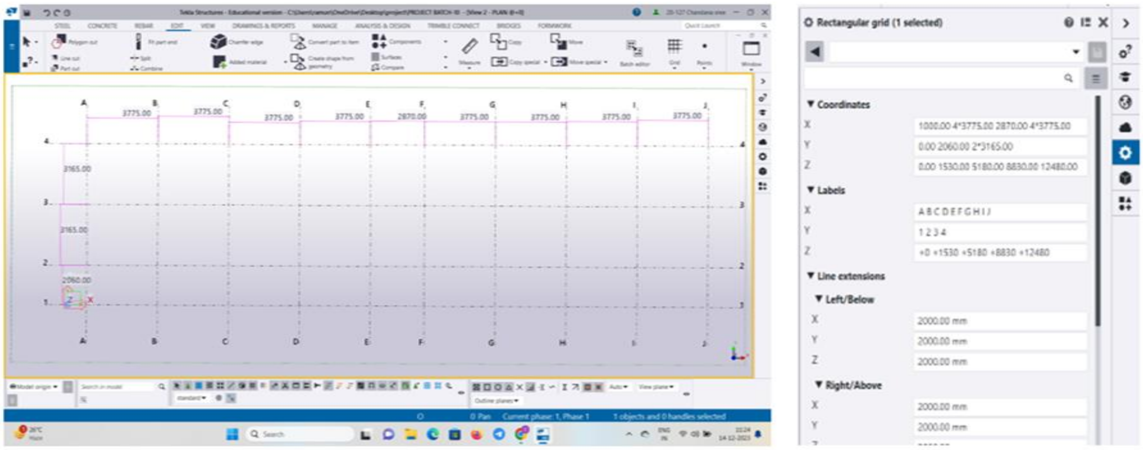
Step-2: Creation of Grids points &Generation structure.
We choose a new model after TEKLA opens, and a window with our building's storey and grid proportions emerges. Create the grids according to plan by entering the values in the dialogue box.



STEP-3: Defining of property.
First, we defined material properties by selecting define menu material properties. By providing the given details in defining, we add a new material for our structural components (beams, columns, slabs). Following that, we determine section size by selecting frame sections as shown below and adding the required section for beams, columns, and so on.

STEP-4 : Placing footings, columns, beams and slab according to plan.
Tekla Structures includes the following components that you can use to automatically construct and adjust reinforcement for beams, columns, and slabs in an open drawing.
Beam: A horizontal structural element that can sustain vertical loads, shear stresses, and bending moments is known as a beam. The loads applied to the beam produce reaction forces at the beam's support points. The sum of all the forces acting on the beam produces shear forces and bending moments within the beam, which cause internal stresses, strains, and deflections.
Column: A column is a vertical structural element that mostly bears compression loads. It is regarded to be the most important structural part of a building because the column strength determines the building's safety. This is due to the fact that the failure of a column would result in the eventual collapse of a building, although such an event would not occur if other members failed. Columns distribute vertical loads from a ceiling, floor, or roof slab to a floor or foundation. They also have bending moments along one or both cross-section axes.
Slab: Slab is a critical structural element that is used to build level and functional surfaces such as floors, roofs, and ceilings. It is a horizontal structural component with parallel or nearly parallel top and bottom surfaces. Slabs are frequently supported by beams, columns (concrete or steel), walls, or the ground. A concrete slab floor's depth is quite tiny in comparison to its span.

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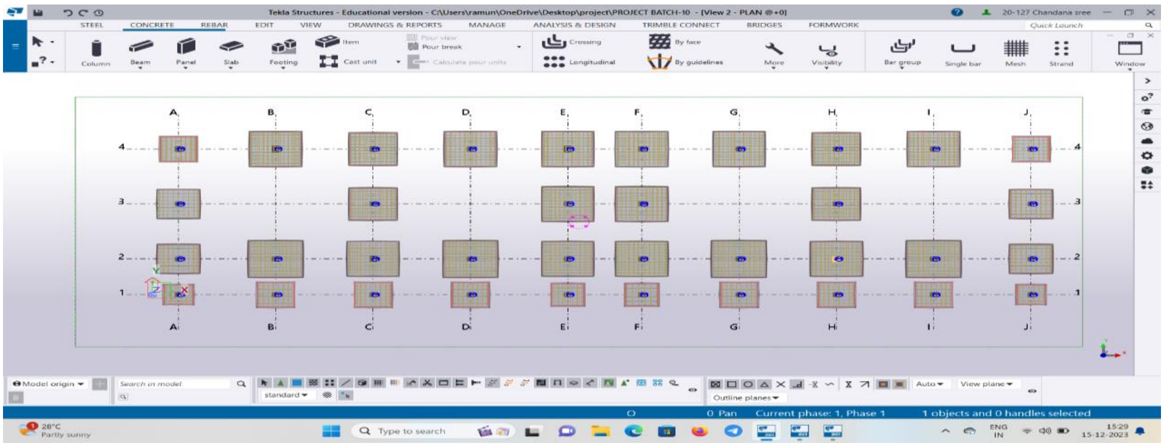

Fig - : Placing of footings

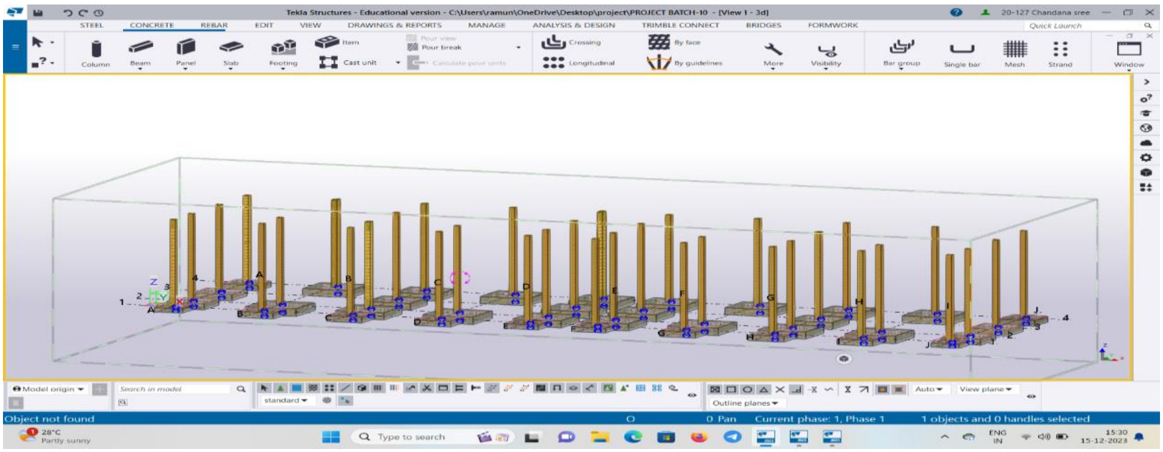

Fig- : Placing of columns

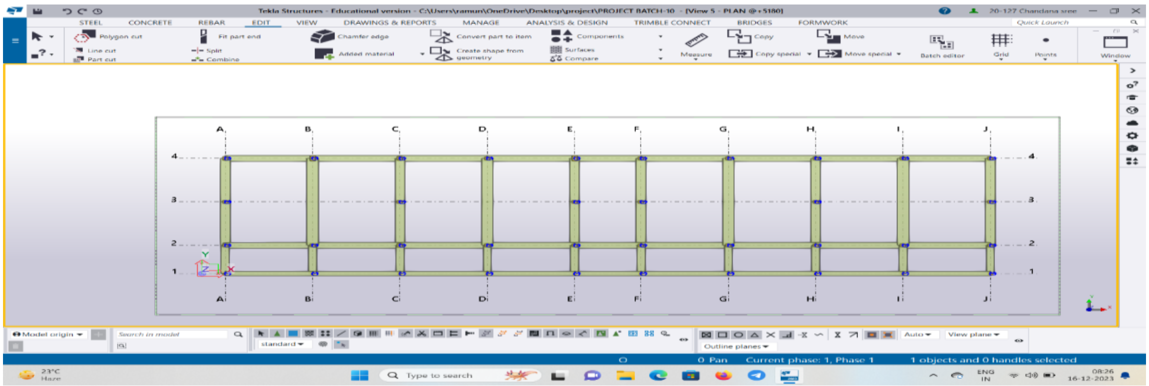

Fig- : placing of Beams

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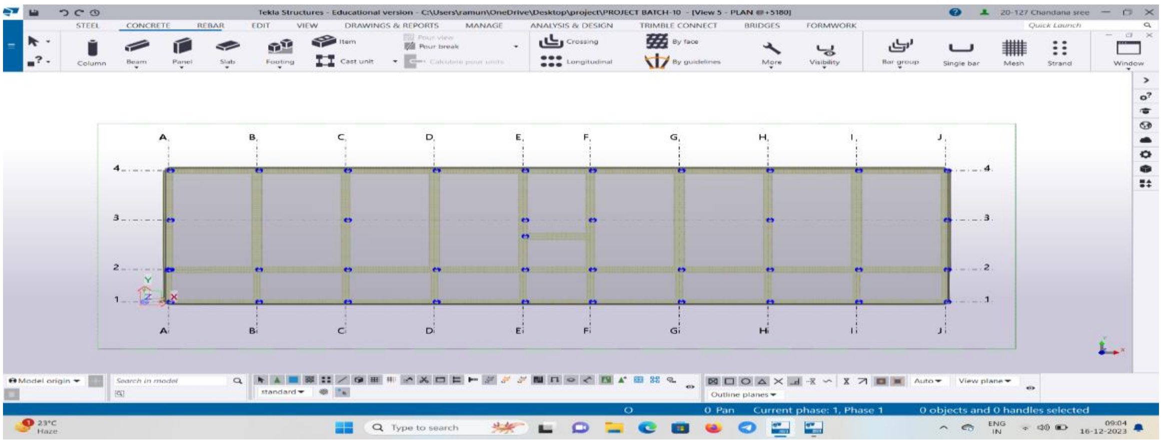
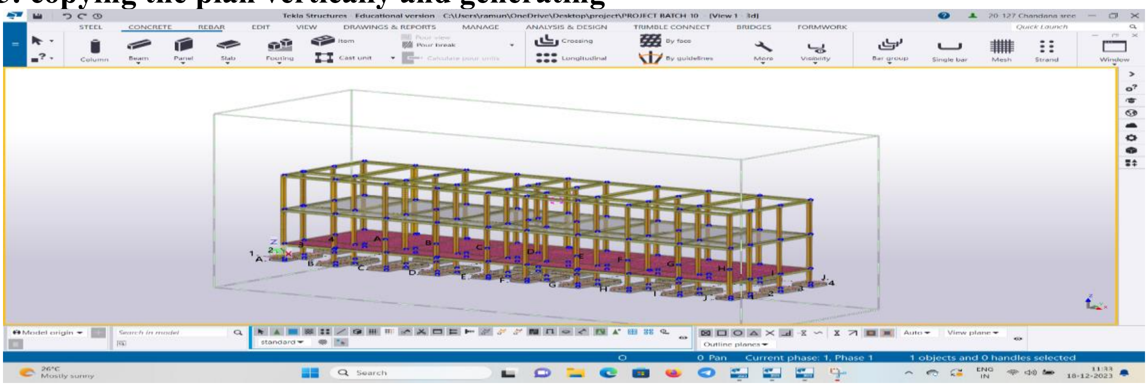


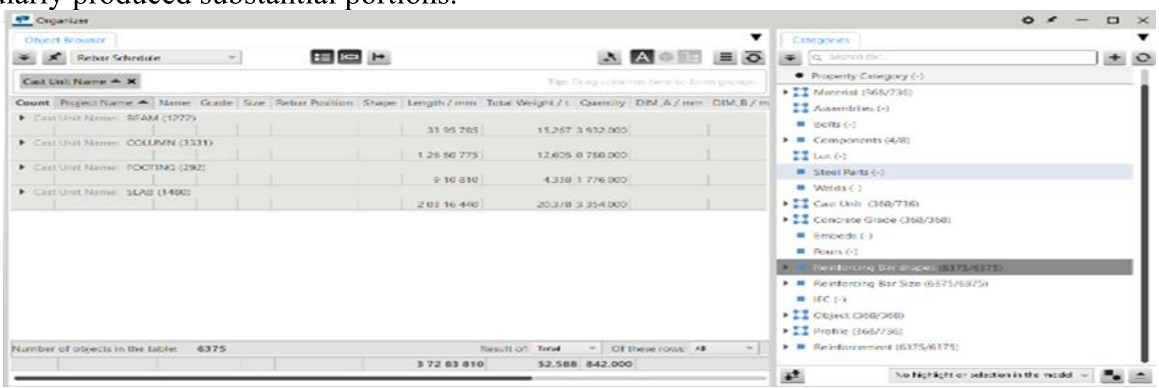
Fig- : Placing of slabs.

Step-5: copying the plan vertically and generating



Step-5: Placing the reinforcement for each component

When you make a support, Tekla Structures appends the support to the part for which you are making the support. If necessary, you can physically link a support to a large section. When the part or cast unit is moved, reproduced, or erased, the connecting supporting bars follow it. Shaft support , which provides support for a cement footer. Pick the cement footer. When you pick the shaft, the support is created automatically. Tekla bars were created. Section Reinforcement Tool provides support to irregularly produced substantial portions.



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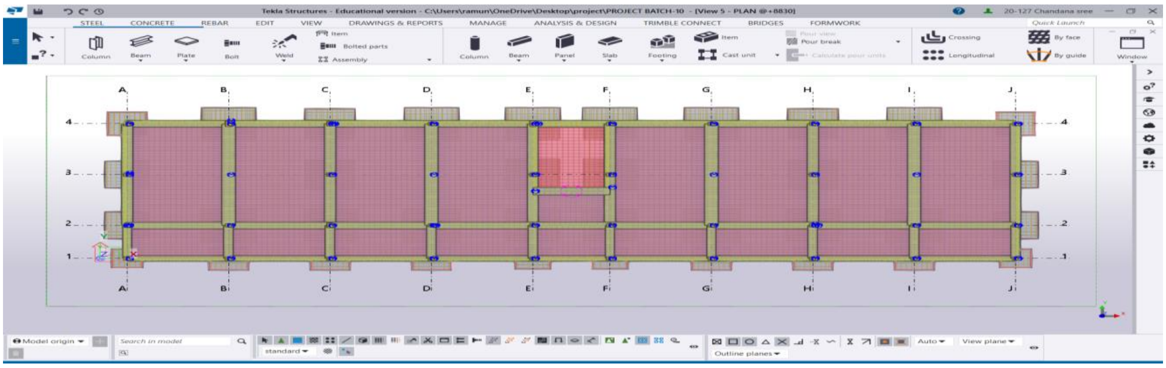

Fig - : Reinforcement in 2D view

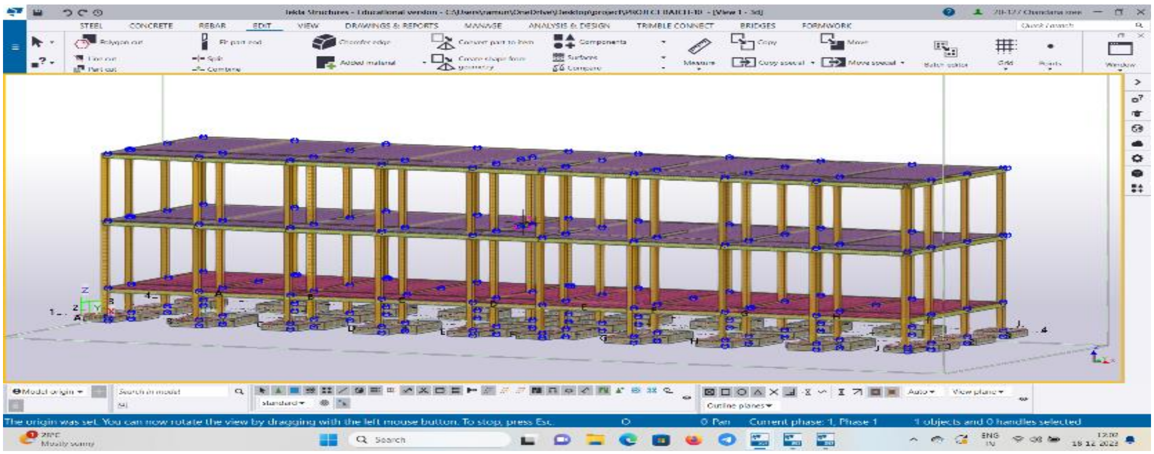

Fig - : Reinforcement in 3D View

Step-6: Generating drawing
Create drawings using the Master Drawing Catalog's different master drawing kinds. Using rule sets is a highly automated approach for making multiple drawings of various types in one go.

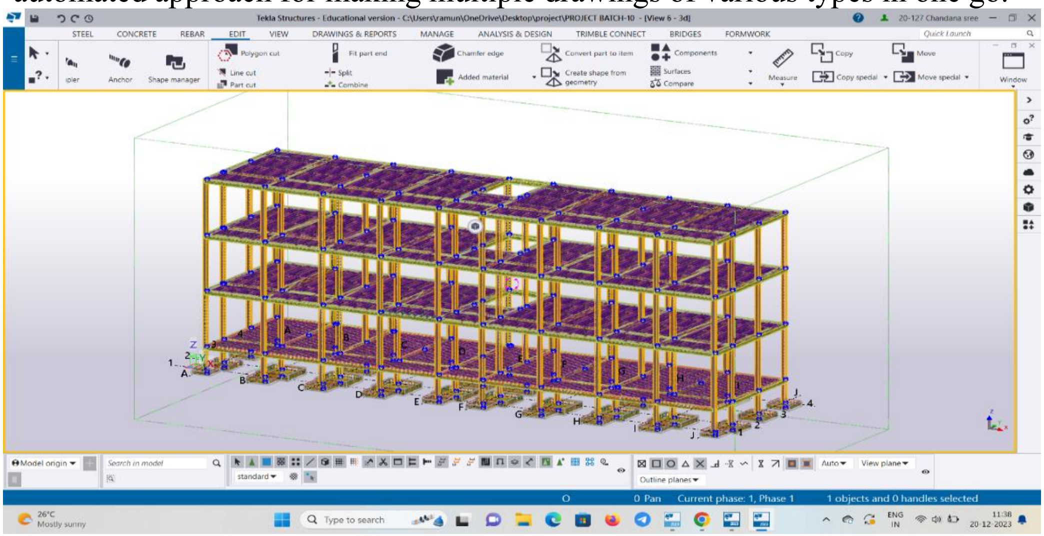

Fig: **3D model of G+ 2 structures with detailing.**

Step-7: Exporting of a 3D model from Tekla Structures to Tekla Structural Designer.

- Tekla Structures models can be exported for usage in Analysis & Design (in a variety of formats). The Analysis & Design results can then be imported back into the Tekla Structures mode
- Various model transfers can be conducted during the project's engineering and contractor phases.

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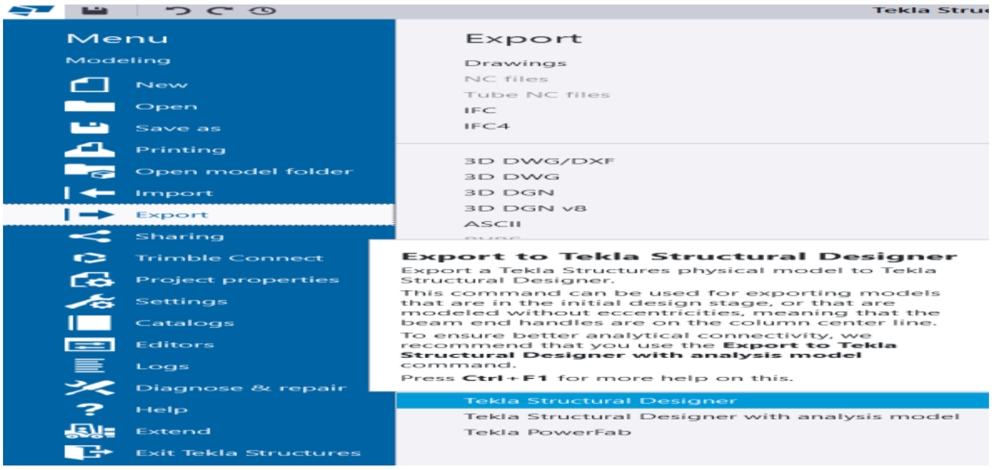
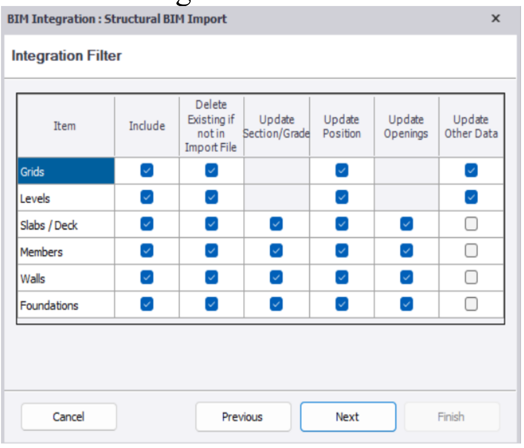
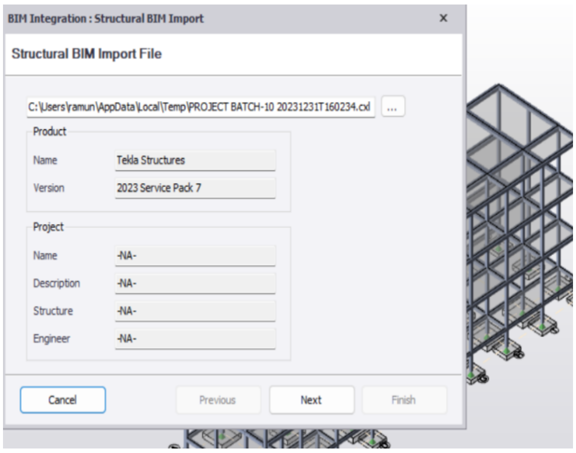


Step-8: Importing of an 3D model from Tekla Structures to Tekla Structural Designer.
After completion of exporting process in Tekla structures the file automatically will open in the Tekla structural Designer software.





Step-9: Defining of loads
In TEKLA, all load concerns are defined first and then assigned. In TEKLA, loads are defined by using the static load cases command in the define menu.

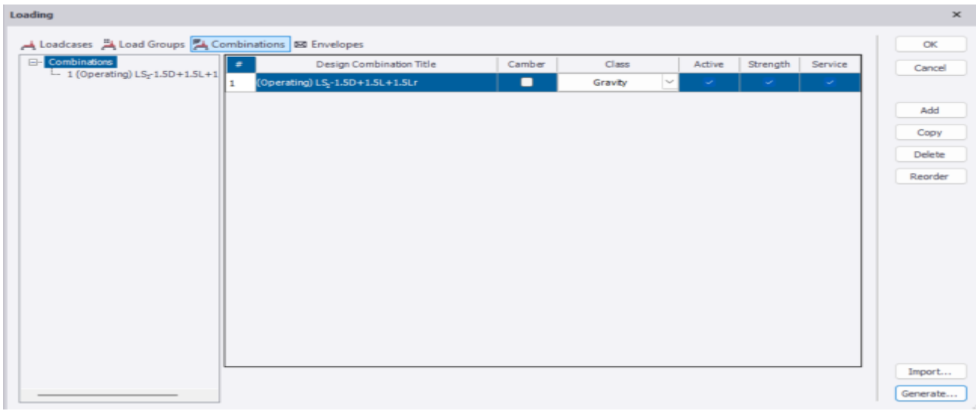
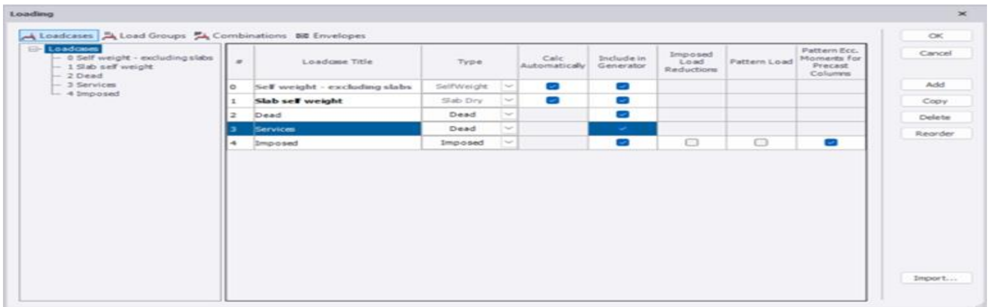
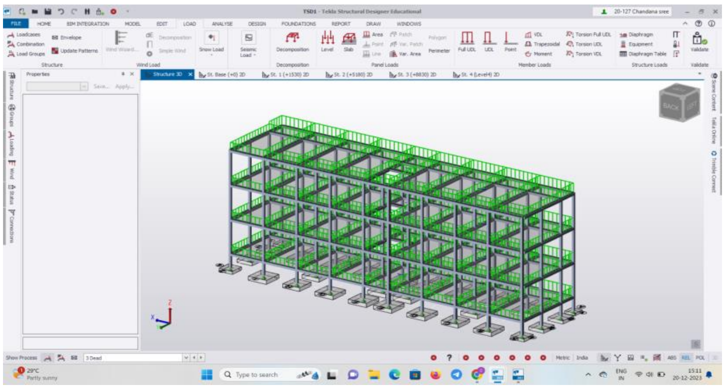


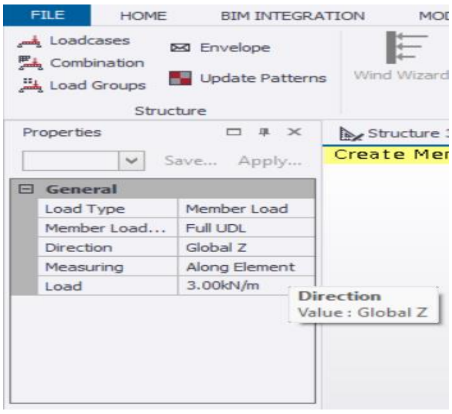
Fig - : Load Combinations



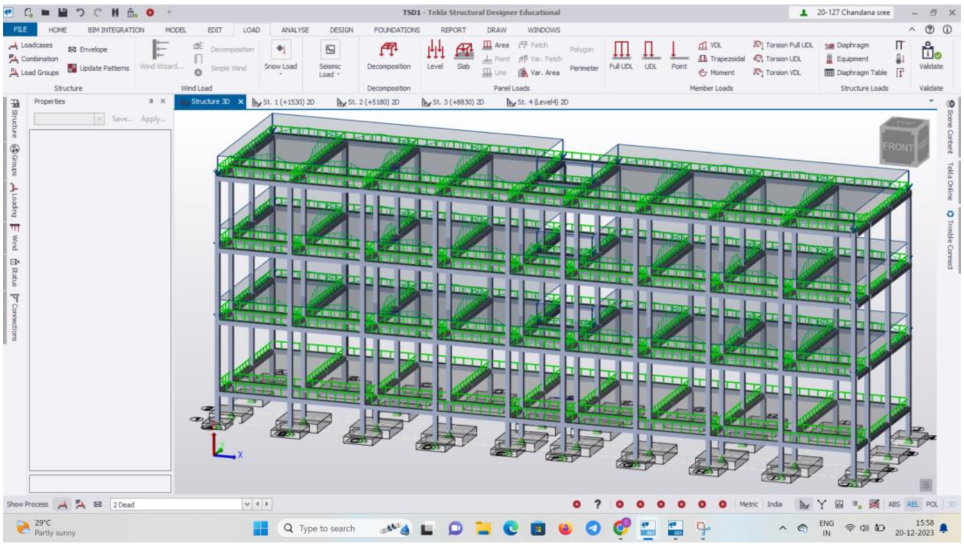
Step-10: Assigning of loads

Dead Load: After defining all loads. Dead loads are assigned to external walls and internal walls in staad, but TEKLA is automatically taken care of by the software, i.e., inbuilt. Add dead loads in the beams.





Live load: The entire structure, including the floor finishing, is allocated live loads.



Step-11: Assigning of load combinations

Using load combinations command in define menu 1.5 times of dead load and live load will be taken.

Step-12: Analysis

After the completion of all the above steps we have performed the analysis and checked for errors.

Step-13: Design

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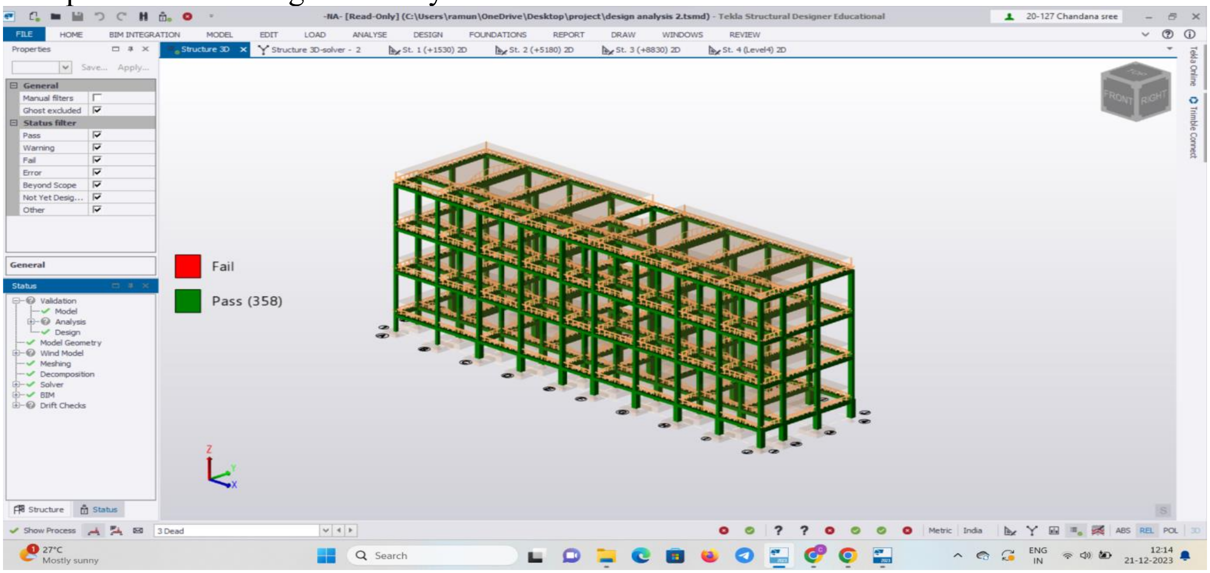
After the completion of analysis we had performed concrete design on the structure as per IS 456:2000. TEKLA performs the design for every structural element.



MODEL IN TEKLA STRUCTURAL DESIGNER.

Results and Analysis:

Tekla structures

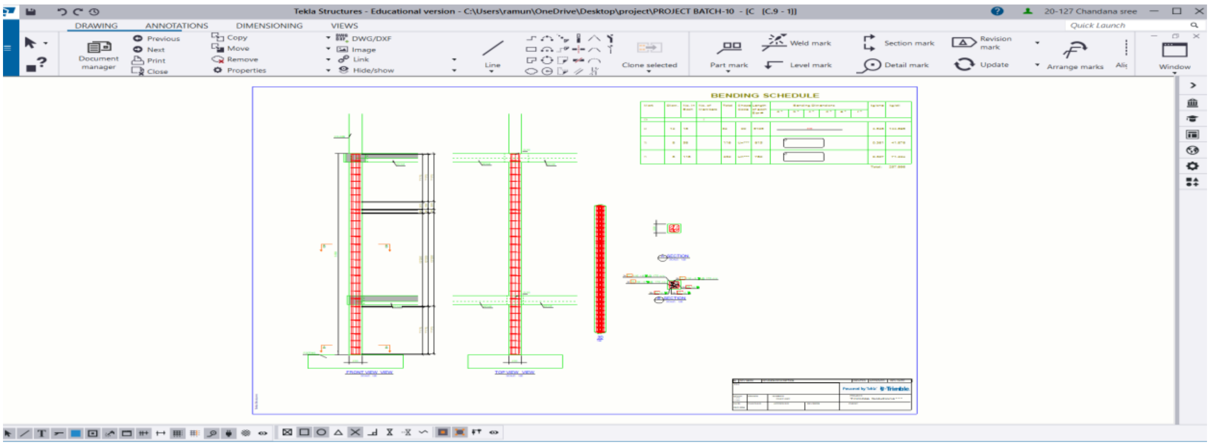


Fig - : column fabrication drawing

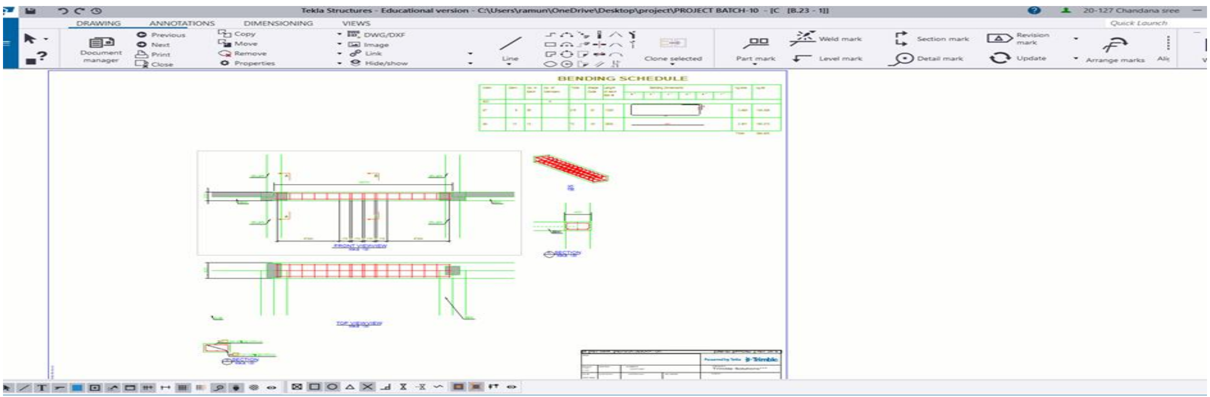


Fig - : Beam fabrication drawing

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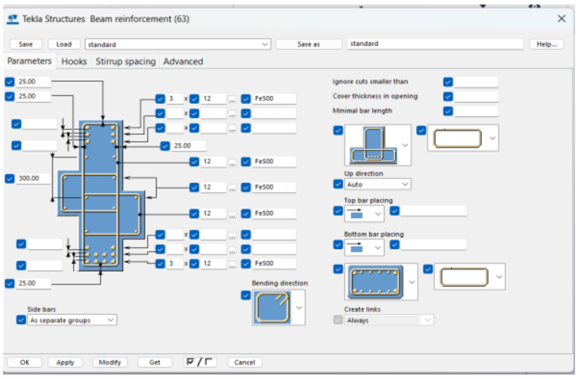
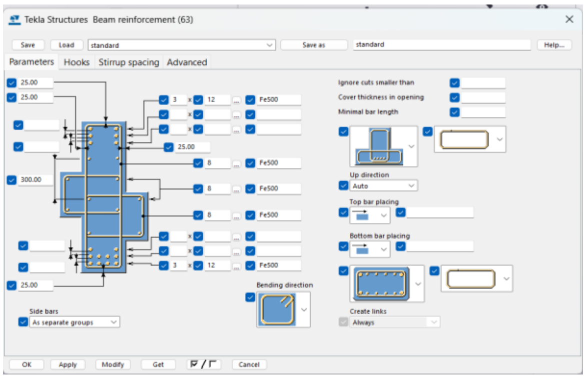
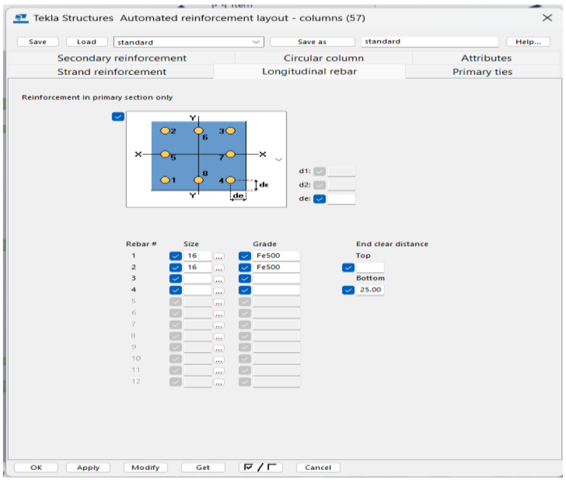


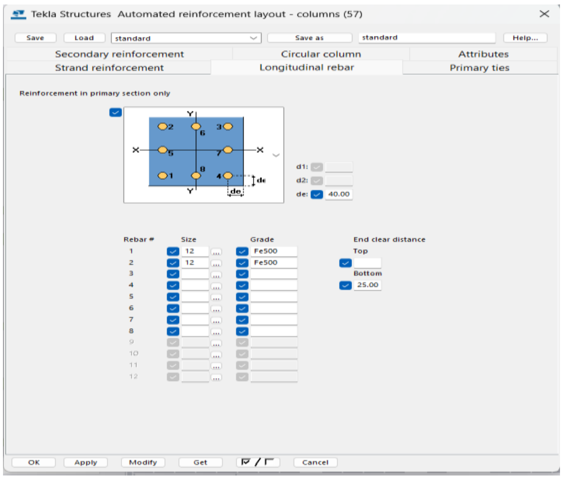
Reinforcement detailing of beam-1



Reinforcement detailing of beam-2



Reinforcement detailing of column-1



Reinforcement detailing of column-2

Tekla structural designer:

Design summary of beams

Static Design Summary

1B34 - 1 300x300 - Critical

Design summary bending top

Region	1
Analysis	FE Chase Down
Combination	1 (Operating) LS_1-1.5D+1.5L+1.5Lr
M_u	10.78 kNm
d	256 mm
d'	44 mm
M_{ul}	81.46 kNm
z	250 mm
$A_{st,req}$	119 mm^2
$A_{st,req,torsion}$	0 mm^2
$A_{sc,req}$	0 mm^2
$A_{stl,req}$	119 mm^2
$A_{st,min,req}$	157 mm^2
$A_{st,prov}$	339 mm^2
Top bars	3T12

Design summary bending bottom

Region	1
Analysis	FE Chase Down
Combination	1 (Operating) LS_1-1.5D+1.5L+1.5Lr
M_u	2.60 kNm
d	256 mm
d'	44 mm
M_{ul}	81.46 kNm
z	255 mm
$A_{st,req}$	28 mm^2
$A_{st,req,torsion}$	0 mm^2
$A_{sc,req}$	0 mm^2
$A_{stl,req}$	28 mm^2
$A_{st,min,req}$	157 mm^2
$A_{st,prov}$	339 mm^2
Bottom bars	3T12
Deflection check	L / d = 6.387 < 58.675

Design summary of columns

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Static
Longitudinal Bars Summary

Stack	Section	Longitudinal Bars	Analysis	Combination	Critical position	Ratio	Status
2	230x230	4T12	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Top	0.329	Pass
1	230x230	4T12	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Bottom	0.454	Pass

Links Summary

Stack	Section	Top support links	Span links	Bottom support links	Analysis	Combination	Ratio	Status
2	230x230	-	1T8-175	-	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.071	Pass
1	230x230	-	1T8-175	-	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.250	Pass

Design Summary

Static
Longitudinal Bars Summary

Stack	Section	Longitudinal Bars	Analysis	Combination	Critical position	Ratio	Status
4	380x230	6T20	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Top	0.168	Pass
3	380x230	6T20	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Bottom	0.151	Pass
2	380x230	6T20	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Top	0.192	Pass
1	400x400	8T20	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Top	0.149	Pass

Links Summary

Stack	Section	Top support links	Span links	Bottom support links	Analysis	Combination	Ratio	Status
4	380x230	-	1T8-225	-	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.154	Pass
3	380x230	-	1T8-225	-	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.113	Pass
2	380x230	-	1T8-225	-	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.061	Pass
1	400x400	-	1T10-300	-	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.129	Pass

Static
Longitudinal Bars Summary

Stack	Section	Longitudinal Bars	Analysis	Combination	Critical position	Ratio	Status
2	230x230	4T12	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Bottom	0.436	Pass
1	230x230	4T12	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	Top	0.510	Pass

Links Summary

Stack	Section	Top support links	Span links	Bottom support links	Analysis	Combination	Ratio	Status
2	230x230	-	1T8-175	-	3D Building Analysis	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.216	Pass
1	230x230	-	1T8-175	-	FE Chase Down	1 (Operating) LS_2-1.5D+1.5L+1.5Lr	0.395	Pass

Beams:

End 1/End 2 + Coincident, First-order linear, All combinations St. 1 (+1530)

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Reference	Span	Section	Grade	End	Condition	Combination	F_x [kN]	F_y [kN]	F_z [kN]	M_x [kNm]	M_y [kNm]	M_z [kNm]
1B34	1	300x300	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	15.89	[illegible]	-7.37	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	[illegible]	[illegible]	[illegible]	6.11	0.00
1B60	1	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	[illegible]	15.66	1.66	-5.35	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	[illegible]	[illegible]	14.72	-1.66	4.59	0.00
	2	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	[illegible]	0.00	39.92	-1.27	-17.55	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	49.45	1.27	25.80	0.00
	3	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	47.13	0.35	-22.81	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	41.42	-0.35	19.83	0.00
1B62	1	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	13.02	-0.33	-3.09	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	16.51	0.33	5.99	0.00
	2	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	40.85	0.44	-19.01	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	47.68	-0.44	24.21	0.00
	3	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	47.14	-0.29	-22.67	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	41.63	0.29	19.97	0.00
1B65	1	425x230	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	30.01	0.18	-14.19	0.00

Reference	Span	Section	Grade	End	Condition	Combination	F_x [kN]	F_y [kN]	F_z [kN]	M_x [kNm]	M_y [kNm]	M_z [kNm]
1B83	8	425x230	M 30	2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	36.56	2.50	[illegible]	[illegible]
1B84	1	300x300	M 30	1	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	116.39	[illegible]	[illegible]	0.00
				2	Min F, Max F, Min M, Max M, Min M, Max M	1 (Operating) LS, -1.5D+1.5L+1.5Lr	0.00	0.00	[illegible]	[illegible]	127.11	0.00

Beam loading and results for major axis:

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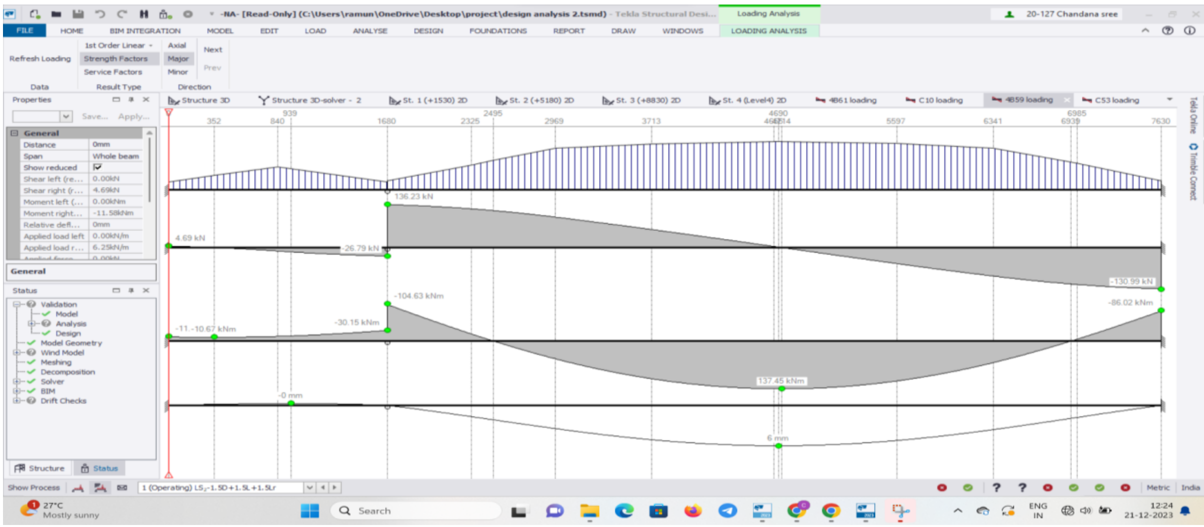

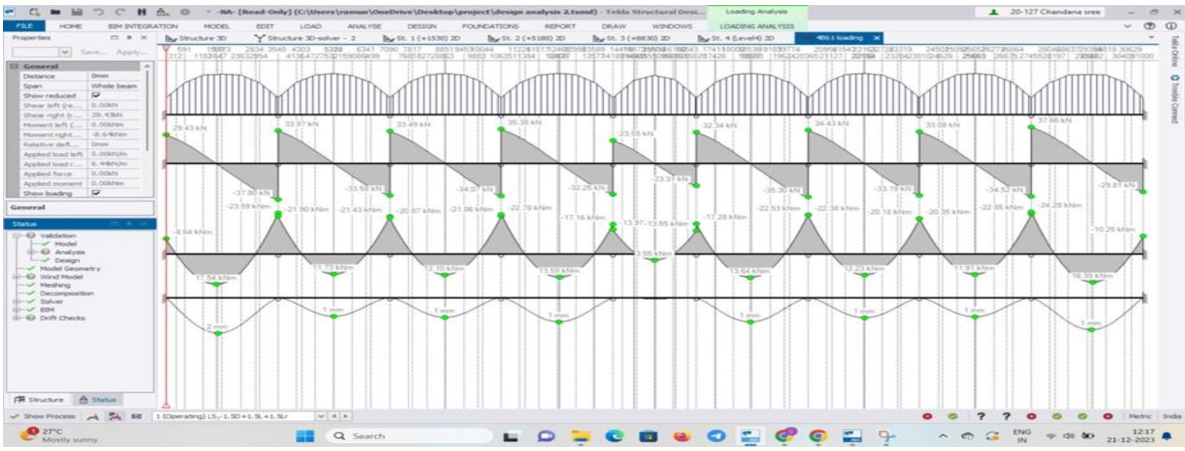

Bending moment, shear force, axial force, Deflection diagrams

Shear Diagrams:

The shear force is the unbalanced external vertical force at a segment. It equals the algebraic sum of the forces on both sides of the section. Upward forces on the left of the section are considered positive, while downward forces are considered negative; signs are inverted for forces on the right. A shear diagram is one in which the shear at each location along the length of a beam is represented as an ordinate.

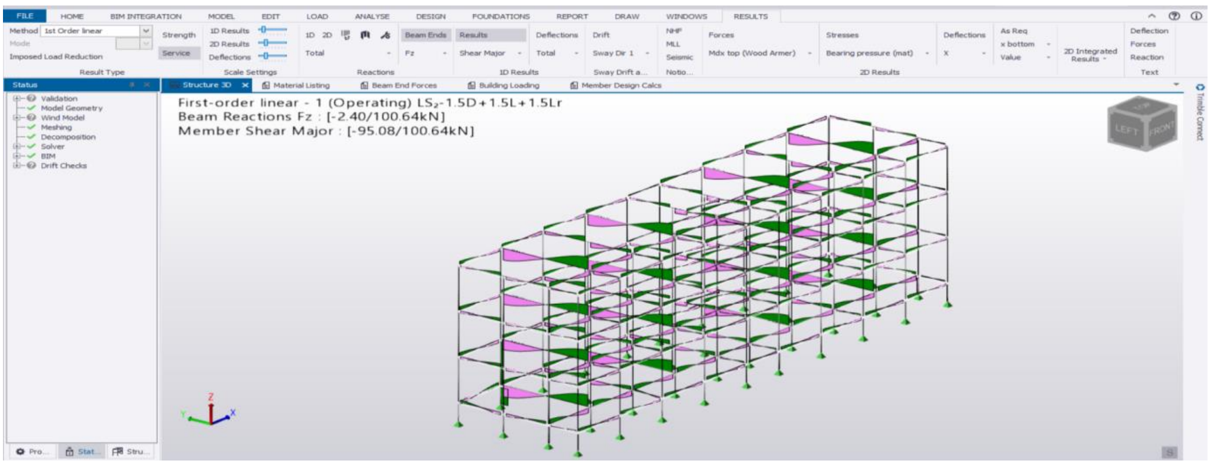

Fig - : Shear Diagram for the Beams with Loads

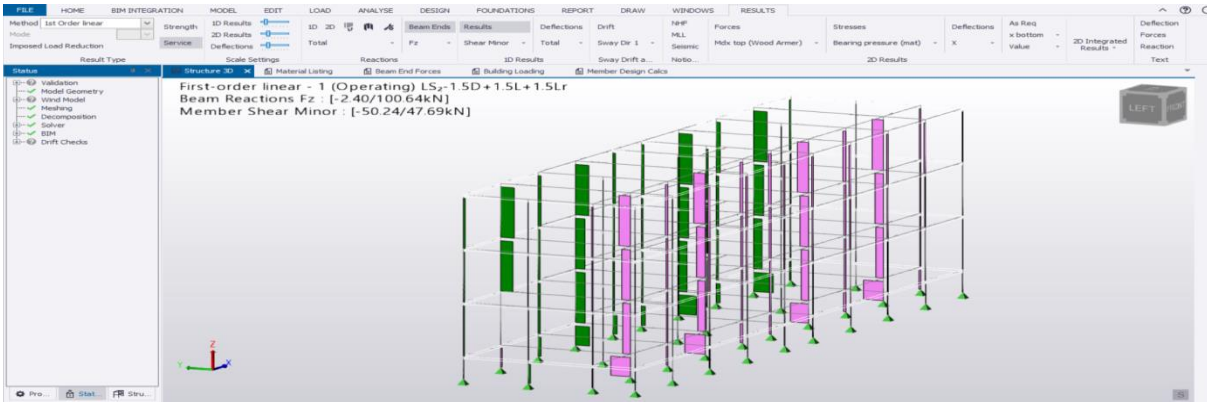

Fig - : Member Shear Minor

Bending Moment Diagrams:

The bending moment is the unbalanced moment of external forces about a vertical passage across a beam. It is equivalent to the algebraic sum of the moments of external forces about the section that lie on one side of the section. When the forces under consideration are on the left side of the section, clockwise moments are regarded positive and counter clockwise moments are considered negative. As a result, when the bending moment is positive, the bottom of the beam is tensed. A bending-moment diagram is one in which the bending moment at each location along the length of a beam is represented as an ordinate. For this simply supported beam, the bending moment at the supports is obviously zero. The bending moment between the supports and the initial load is related to the distance from the support because it is equal to the reaction times the distance from the support. As a result, the bending-moment diagram for this section of the beam is a slanted straight line.

If the bending moment and shear at any segment of a beam are known, the bending moment at any other section may be estimated, provided no unknown forces exist between the two sections. The bending moment at any part of a beam is equal to the bending moment at any section to the left, plus the shear at that section multiplied by the distance between sections, minus the moments of intervening loads. If the portion with the known moment and share is on the right, the sign convention must be flipped.

Conclusion:

Tekla Structures is a comprehensive tool that encompasses the whole structural design process in a single environment. It permits the usage of a single BIM model from the conceptual stages all the way through to fabrication, and its capacity to reuse data across design, analysis, and detailing phases, as well as model in steel, concrete, and timber, is fairly unique in the industry. This software is quite powerful in terms of modelling. This program excels at bridging the gap between design and manufacture, and its unified environment provides the ideal conduit for data to flow easily from engineer to detailer. Most importantly, it has the ability to simplify the management of an often-fragmented process, resulting in improved cooperation, better designs, shorter turnaround times, and lower costs.

The design of the column, beam, footing, and slabs is done in the limit state approach, which is safe for deflection control, and in all aspects utilizing Tekla software, the design considerations have been considered according to IS Codes. In comparison to sketching, manual design, and the geometrical model created with Tekla, the design is safe in all scenarios. The area of Ast required for the beam, column, footing, and slab is comparable to the area of necessity. While software provides required bar and member sizes, it does so with a safety factor.

Tekla can calculate the necessary reinforcement for any concrete section. The program includes a variety of parameters that are designed in accordance with IS456:2000. Beams are built to withstand flexure, shear, and torsion.

Tekla structural designer includes comprehensive documentation and reporting capabilities, as well as the ability to work with both concrete and steel structures, extensive analysis and design capabilities, a Finite Element engine that allows it to perform complex and accurate analyses, the ease of creating loads and combining them into load cases and combinations, automated design capabilities, and the ability to review analysis results.
LSM theory provides suitable strength, serviceability, and durability in addition to economy. The displacement, shear force, and bending moment variations have been demonstrated. If any of the beams fails, the beam and column proportions should be altered, and reinforcement details can be constructed.

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