Multi-Storey Steel Office & Teaching

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Abstract： This thesis paper explains with a certain amount of details the whole process involved in the design of a Multi-layer steel construction, from the preliminary architectural design to the final structural detailed drawings. As it is specified in the project description, structural steel being quite popular for the recent 30 years, it's been fruitful to experience the efficiency of the structural steel properties during the design process and achievement. To accomplish this Design, we mainly used licensed software by Autodesk, including Revit Structures for the architectural design and Robot Structural Analysis professional for the structural analysis and design.

Keywords： Steel Structure; Multi-layer Building; Architectural & Structural Design；Structural Analysis.

多层钢结构办公与教学综合楼设计

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摘要：本文详细阐述了多层钢结构建筑及结构设计的全过程, 从初步建筑设计到最终的结构详细图纸。正如工程描述中所指出的, 钢结构建筑在近 30 年来相当流行, 通过设计过程和设计成果，非常有效的体验了钢结构的各项性能以及所带来的优势。为了完成这一设计，我们主要使用 Autodesk 授权的软件, 包括用于建筑设计的 Revit 结构和用于结构分析和设计的专业结构分析程序。

关键词：钢结构； 多层建筑；建筑与结构设计；结构分析

Introduction

We are living in an absolutely wonderful era, where technology is constantly evolving. When a few years ago it would take month to completely design and analyze a Multi-story structure, nowadays within hours the process can be completely given appropriate data, rendering extremely precise results. Steel being a wonderful material, which has been used for quite a few years now, makes the process of designing and analyzing it a must, which can't be ignored in the field of civil engineering.

Throughout the process experience can be gained while dealing with the diverse and versatile properties of steel, which have to be controlled carefully. Buckling, fire, and many other aspects affecting the good performances of steel.

Using specific software like Autodesk Robot and Revit, we can save a considerable amount of time, while checking and analyzing the whole structure, just a few clicks away. The fact they interconnected is an advantage that can't be neglected. Without further words, let's get into the core of our project.

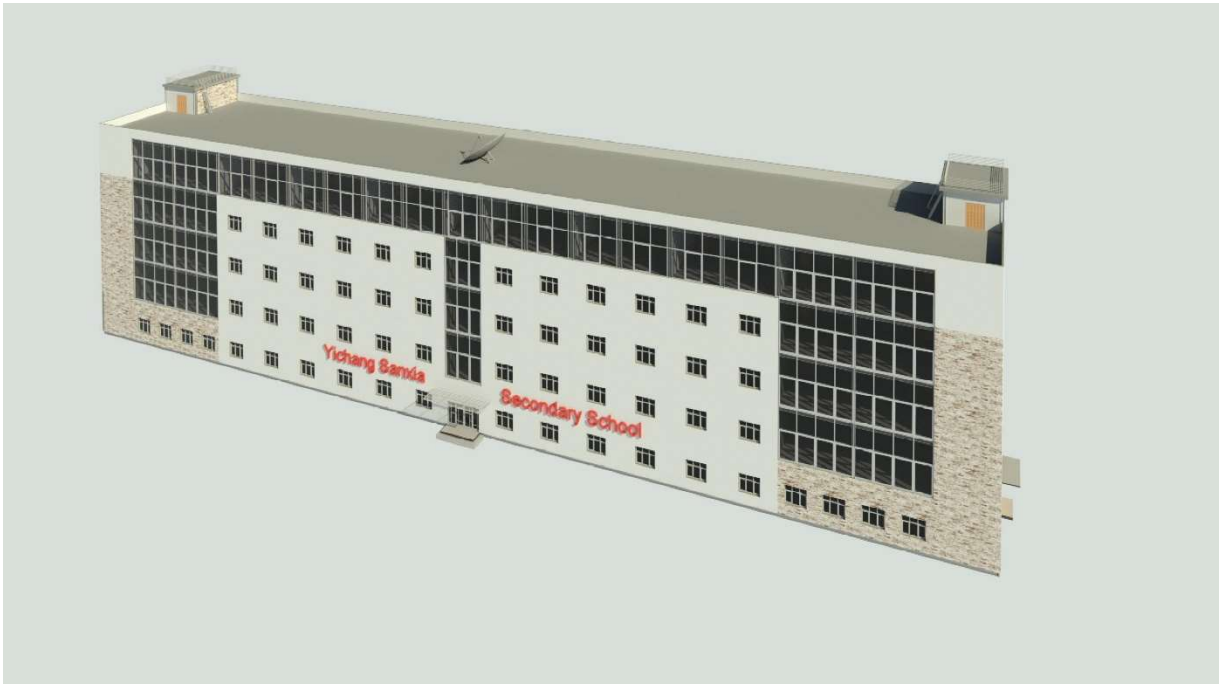
1 Architectural design

1.1 Structure philosophy

The philosophy on which I based my structural design is meant to be modern with a slight touch of classic methods of architectural designs.

The space management and the room arrangement is particularly inspired by the J building of china three gorges university campus, a teaching building and an office building,

suitable framework which largely satisfy the functional requirements of an Office and Teaching Building which is our goal, and smoothly laid for us a very good foundation for the next work ‘structural design’’.



1.2 Structure description

The structure consists of:

A teaching building:mainly made of classrooms, and Offices. The structure is mainly inspired from the J building, in china three gorges university campus;

Preliminary design

The first step into the design process was the preliminary design, I had to think about the shape, the rooms' functions, the building orientation, the number of buildings and every single aspect of the future building. And using sketches and hand drawn sketches, I designed the first look of the structure.

Detailed design

The detailing then has to be done with respect to the design specifications and Chinese codes relative to steel structures. Drawings (architectural and structural) will then be exported to dwg format, and mastered in AutoCAD.

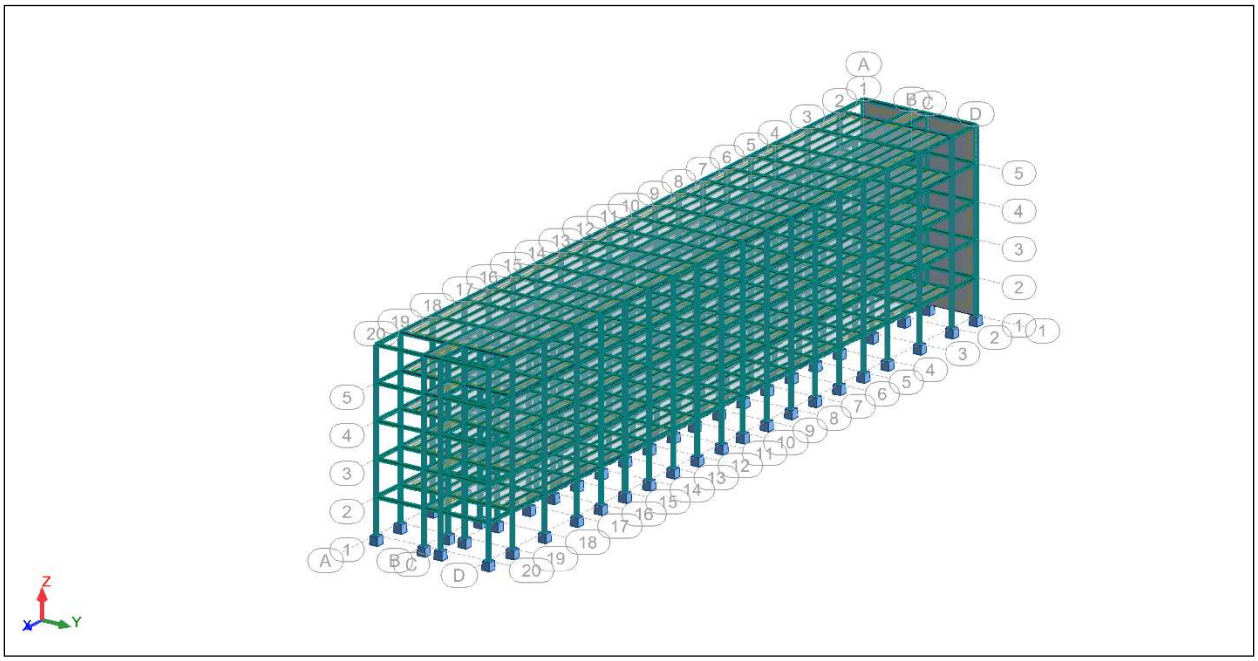


Fig. 1.2 Autodesk Revit User interface

2. Structural Design and analysis

2.1. Design Process

To reach the structural Design and analysis process step, the architectural design must be completely done. The transfer from Autodesk Revit to Autodesk Robot can then be made, transforming the structure into an analyzable Frame. Different load cases can then be applied to the different assumed structural members, and load combinations are automatically generated by the software according to the Chinese code relative to the steel design. Most adverse situations for every single members are shown in detailed reports, where it shows us whether the member is safe or not, and corrections can be then made to the unsafe structures, and the calculations done again until every member is safe.

After the structural checking process, we can then move to the design of connections, for typical kind connections (beam-to-beam, beam to column…) on the most loaded corners. And finally the RC members in the building; slabs, stairs and foundation. Reinforcements for the selected thicknesses are then provided after the calculations depending on the load combinations, and finally the reports can be generated.

The last step but not the least, is the seismic analysis, which is a modal one still based on the Chinese code for seismic design, with a minimum of 90% of mass participation for the structure to be safe. The checking is lunched, and in our case the response is positive. With all the calculations safe, we can see the results in the following points.

2.2. Design and analysis results

2.2.1. Structural members : columns, girders and beams

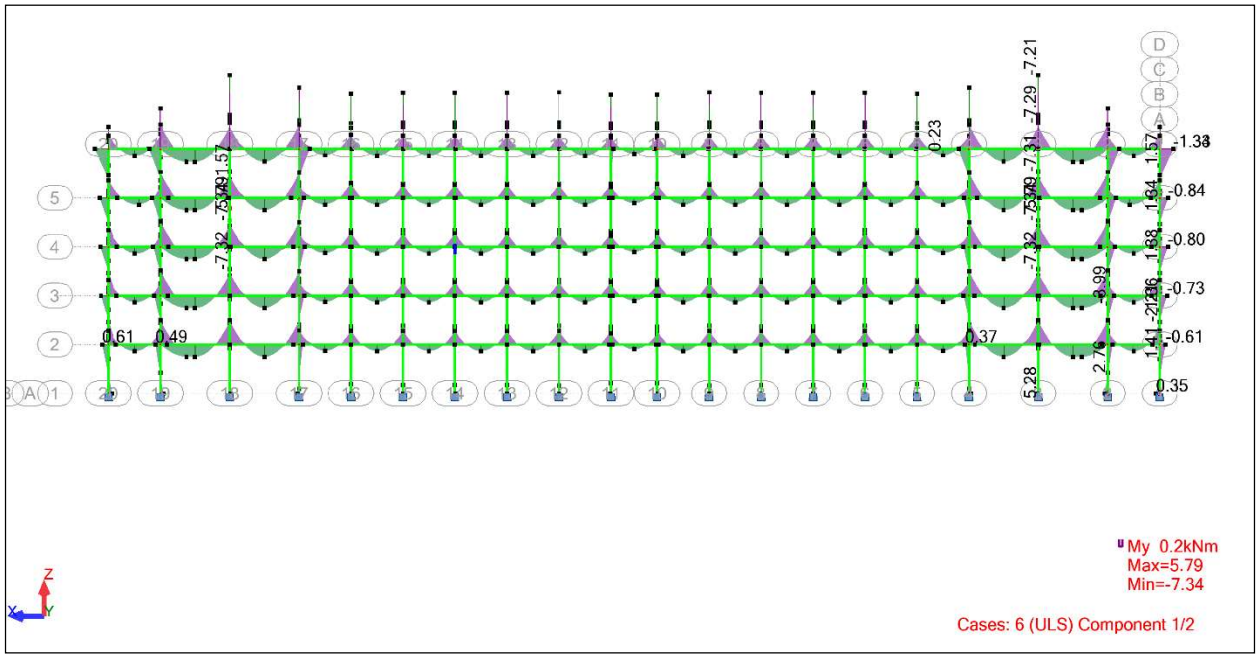


Table 2.1 Sections Data

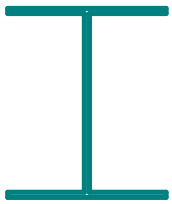
Section name	Bar list	AX (cm2)	AY (cm2)
H 350x300x0	37to54 58to65 67to98 264to289 291to322 373to398 400to431 4-99to509	98.10	72.00
I 33	135to137 139to141 144to146 1-48to150 152to154 156to158 16-0to191 323to372 432to481	53.80	31.36
HW 400x1	1to36 192to263 491to498	197.80	144.00

Section name	AZ (cm2)	IX (cm4)	IY (cm4)	IZ (cm4)
H 350x300x0	28.00	40.12	22880.00	5400.00
I 33	23.10	16.63	9840.00	419.00
HW 400x1	54.00	305.35	57678.00	10817.00

Section properties

Section properties:

H 350x250x0

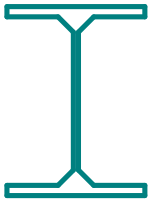


HY=30.0, HZ=35.0 [cm]
AX=98.10 [cm2]
IX=40.12, IY=22880.00, IZ=5400.00 [cm4]
Material=Q235

I 28

HY=14.0, HZ=33.0 [cm]
AX=53.80 [cm2]
IX=16.63, IY=9840.00, IZ=419.00 [cm4]
Material=Q235

HW 400x1



HY=30.0, HZ=40.0 [cm]
AX=197.80 [cm2]
IX=305.35, IY=57678.00, IZ=10817.00 [cm4]
Material=Q235

Table 2.2 Materials Data

	Material	E (MPa)	G (MPa)	NI	LX	RO	Re

					(1/°C)	(kN/m3)	(MPa)
1	Q235	206000.00	79000.00	0.30	0.00	77.01	215.00
2	Q345	206000.00	79000.00	0.30	0.00	77.01	310.00
3	STEEL	206000.00	79000.00	0.30	0.00	77.01	215.00

Table 2.3 Supports Data

Support name	List of nodes	List of edges	Support conditions
固定	1to71By2	-	UX UY UZ RX RY RZ

Table 2.4 Load Cases

Case	Label	Case name
1	DL1	DL1
2	DL2	DL2
3	LL1	LL1
4	LL2	LL2
5	WIND1	WIND1
6	SN1	SN1
7		ULS
8		ULS+
9		ULS-
10		SLS
11		SLS+
12		SLS-

Case	Nature	Analysis type
1	dead	Static - Linear
2	dead	Static - Linear
3	Live 1	Static - Linear
4	Live 1	Static - Linear
5	wind	Static - Linear
6	Snow I	Static - Linear
7		Static - Linear
8		Static - Linear
9		Static - Linear
10		Static - Linear
11		Static - Linear
12		Static - Linear

Table 2.5 Load values

Case	Load type	List	Load values
1	self-weight	1to54 58to65 67to98	PZ Negative Factor=1.00