Modelling Civil Engineered Systems

Technische Universität Berlin

Institut für Bauingenieurwesen

2st Assigment-Parametric Modeling

Framed structural engineering

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Defining the design thema

The domain in which I created the parametric model is the frame structure, and the main ideas that represent the basis of the parametric model of the frame structure are beams, slabs, and columns. The following parameters are chosen as control parameters for the parametric model:

- Building span (L);
- Floor height;
- Beam height (h);
- Beam width (b);
- Beam width to height ratio (b/h);
- Beam span (L0);
- Slab thickness;
- Column section size;
- Depth of foundation.

The purpose of these parameters is to define and adjust the geometric characteristics in the frame structure to meet the design requirements and performance criteria. Specifically:

Span: controls the dimensions of the whole structure, affects the stability and load carrying capacity of the structure, and has different span requirements for different buildings

Floor height: defines the longitudinal dimension of the whole structure, which has an important influence on the vertical load carrying capacity and stability of the overall structure.

Beam height: affects the bending stiffness and load carrying capacity of the beam, and plays a key role in the horizontal load distribution and deformation control of the structure.

Beam width: affects the lateral stiffness of the beam and the horizontal stability of the overall structure.

Beam Width to Height Ratio: defines the cross sectional shape of the beam and has an important influence on the load carrying properties and deformation behavior of the structure.

Slab thickness: controls the strength and stiffness of the structural slab and affects the horizontal load distribution and deformation of the structure.

Column section size: defines the geometry of the column, which plays a key role in the vertical load carrying and stability of the whole structure.

Foundation depth: affects the stability of the structure's foundation, especially in uneven or unstable soil conditions.

By adjusting these parameters, the performance of the structure can be optimized for specific engineering needs and design criteria, ensuring that it performs well in terms of withstanding loads, meeting safety standards, and satisfying design requirements. The flexibility of these parametric models allows engineers to effectively optimize and adjust them during the design process to meet the specific needs of different projects.

Defining the input parameters

My intention of choosing frame structure in the ontology construction is to understand the system of frame structure, and does not involve the actual project, because many buildings can be constructed with frame structure, such as multi-storey houses, hotels, office buildings, schools, etc.

My purpose is to allow the builder to have a flexible option of choosing the frame structure as the main structure in designing, in order to better satisfy the needs of different types of buildings. The aim is to provide a generic and adjustable model so that architects and design teams can freely adjust parameters such as span, storey height, beam height, beam width, slab thickness, column cross-section dimensions and foundation depth according to the requirements of a specific project, in order to realize a precise control of the overall form and structural performance of the building. So in this parametric modeling, I take the reference in the ontology modeling, my university graduation design, high-rise hotel as an example to model, in this modeling, I do the simplification treatment, but keep most of the data. This is because depending on the type of structure, like the height to span ratio of the beams are different, but all the parameters can be defined by entering the proper criteria. The specific parameter values are as follows

Input Parameter	Min. value	Max. Value
Span（x）	16800mm	100000mm
Span(y)	10000mm	50000mm
Beam span(L0)	3000mm	7800mm
h/L0	1/18	1/10
Beam height: h	383.33mm	780mm
b/h	1/3	1/2
Beam width: b	200mm	300mm
Floor height	3000mm(standard floor)	4500(first floor)
Column side length	600mm	800mm
Slab	100mm	120mm

According to the formula $A_c = b_c h_c \geq \frac{N}{\mu_N f_c}$, the cross sectional area of the columns can be calculated, because the bearing capacity of each floor is different, and the size of the columns varies from floor to floor, so in this parametric modeling I differentiated between the first floor columns and the standard floor columns, because the first floor is usually higher than the standard floor height. In the modeling, the foundation part made a simplification by using foundation columns to symbolize the foundation.

Two design parameters

In this modeling, two important design parameters are verified as they affect the physical embodiment of the product.

The first is the beam width-to-height ratio

The width-to-height ratio of a beam is directly related to the shape of the cross-section, which has a significant impact on the strength and stability of the beam. A reasonable aspect ratio ensures that the beam is not prone to instability phenomena such as bending and buckling when subjected to loads, thus maintaining the overall stability of the structure.

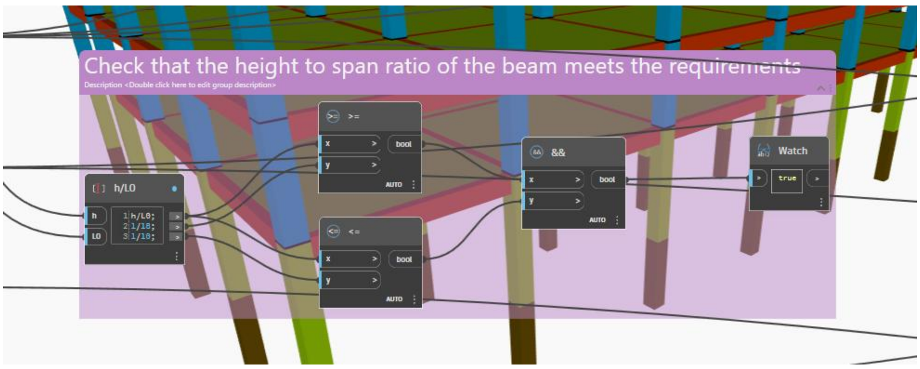
The width-to-height ratio of a beam is also related to the shear load carrying capacity of the beam. Excessively large or small width-to-height ratios may lead to lateral twisting effects, affecting the shear performance of the beam. The load carrying capacity of beams in the shear direction can be improved by appropriate width-to-height ratio design.
In addition to this, too extreme beam cross-sectional shapes may increase the difficulty and cost of construction. Therefore, the limitation of aspect ratio can also ensure that the beam cross-section shape is feasible and economical during construction.

The second is the beam height-to-span ratio
The beam height-to-span ratio directly affects the bending performance of the structure. An excessive beam height-to-span ratio may result in an excessively soft beam, making it prone to excessive deflection under loading and affecting the stability of the structure. A reasonable beam height-to-span ratio helps to balance the strength and stiffness of the structure and ensures that the beams are able to deflect moderately under load without losing stability.
The deflection of a structure is a parameter that needs to be tightly controlled in design, especially for buildings that need to be kept level or are sensitive to deflection. By limiting the beam height-to-span ratio, the deflection of the structure can be effectively controlled to ensure that the structure does not exceed the allowable deflection limit under load.
A reasonable girder height-to-span ratio usually helps to improve the lateral movement resistance of the structure, making the structure more stable in the horizontal direction. Excessive beam height-to-span ratios may make construction more difficult and require larger formwork and bracing systems.

Three good alternatives

In fact, a structure can be replaced by a number of programs, mainly depending on the focus of the designer wants, there is no best design program, only the most suitable design program.

Option 1：
Use a smaller beam height-to-span ratio. Such a structure is relatively rigid. The overall stability of the structure is improved because of the smaller deflection; it is relatively easy to construct. So I adjusted the high beam span in the model and the validation showed a pass.

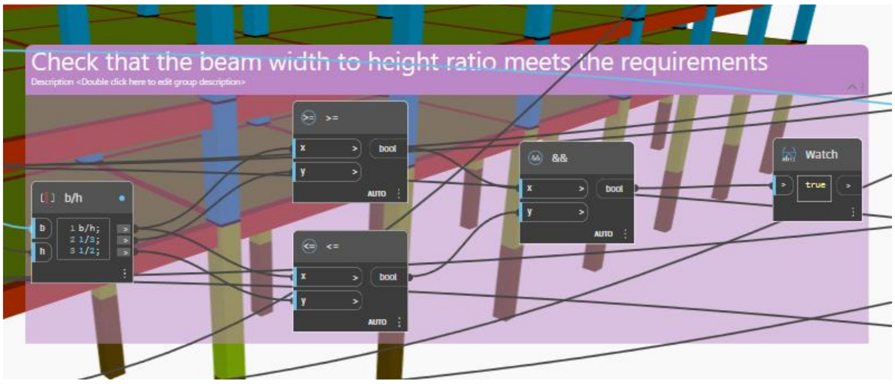


Option 2：

Reasonable arrangement of floor functional partitions. The arrangement of the functional partition of the floor has a great influence on the structure. Since each room has a different function, the corresponding live loads are different. For example, the office area may be subject to more static loads than the rest area, while the conference room may need to consider the concentrated dynamic loads. Such differences need to be reasonably considered in the structural design. Different countries and regions have their own building codes, which should be followed to find the most reasonable layout requirements.

Option 3：

Increase the width-to-height ratio of the beam. This improves the flexural strength of the beam, making it more adaptable to long spans, reducing deflection and improving the stability of the overall structure. And the aspect ratio of the beam is related to the cross-section shape of the beam, which also affects the use of reinforcement. So I adjusted the width of the beam to 300mm in the model, and the verification shows that it is qualified.



Final Presentation