

How to design hyperstatic rigid frames insightfully with graphic statics ?

0. PAPER TITLE AND KEY WORDS:

- a Geometric-based Method for the Perceptive Design of Hyperstatic Rigid Frames
- KEY WORDS: hyperstatic rigid frame, graphic statics, perception, structural design

1. PROBLEM STATEMENT:

Drawbacks of the current design methods for members of hyperstatic rigid frames

- Not insightful into the relation between form and forces.
- One-way approach: results are also not interactive
- Demanding of mathematics knowledge



- Trial-and-error approach with “black-box” tools
- Architects are deterred from in-depth form-finding of frames



- Often materially-inefficient
- Aesthetic value is often unexploited

2. METHOD: GRAPHIC STATICS

○ **Key techniques for rigid frames:**

- Frames are rotated into continuous beams
- Using trail bending moment for hyperstaticity
- Using elastic curves to check and adjust

○ **Advantages of graphic statics:**

- insightful into the relation between form and forces.
- Two-way approach
- Less demanding of mathematics knowledge

○ **Limitations to overcome:**

- Slow and cumbersome with hand-drawing
- limited to orthogonal portal frames under vertical loading
- imprecise for frames with static indeterminacy more than one degree

3. FURTHER DEVELOPING GRAPHIC STATICS

- a solution for portal frames under horizontal loading
- The portal frames with oblique members.
- The presentation of multi-story and multi-span frames
- address the static indeterminacy more precisely

4. PARAMETERIZING

○ **Purposes:**

- speed
- Accuracy
- Interactivity

○ **Environment:**

- Grasshopper+ python

5. DISCUSSION

○ **Advantages**

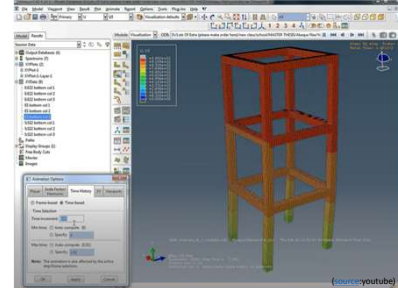
- Very insightful
- chronology-free
- Less demanding For mathematics

○ **Limitation**

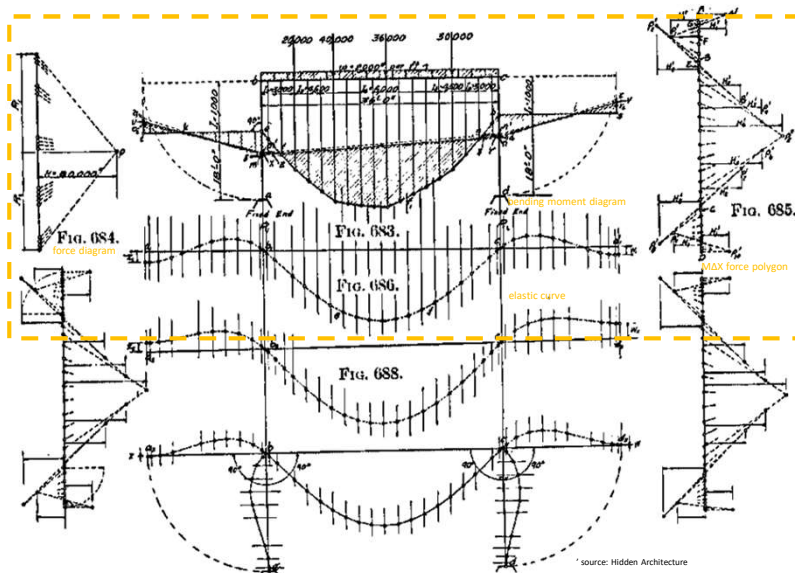
- high degree of indeterminacy
- Interactivity is still limited



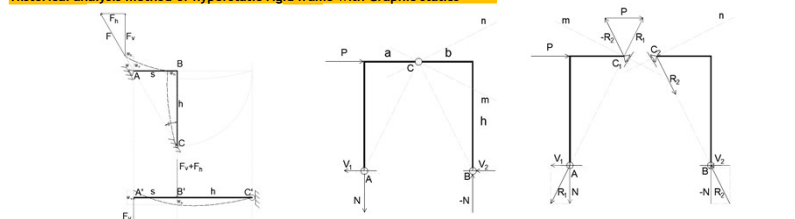
An example of well-designed hyperstatic rigid frame



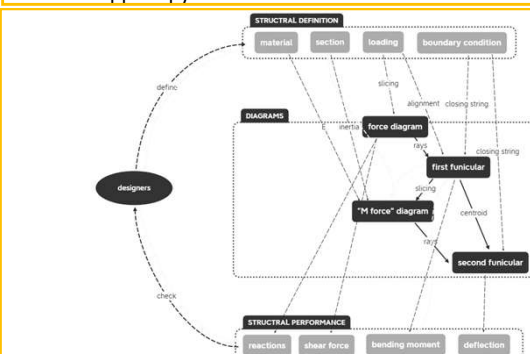
FEM analysis of a hyperstatic rigid frame



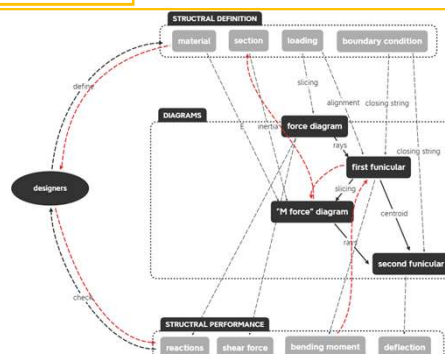
Historical analysis method of hyperstatic rigid frame with Graphic statics



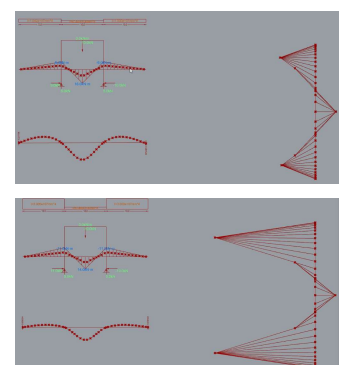
Further developing graphic statics



One way chronology method



Two way chronology-free method



Parameterization