Idee, wenn man so ehrgeizig sei und mit Männern auf Augenhöhe sein wolle, sei dies unvereinbar mit der Idee, mit einem potenten Mann eine Liebesbeziehung und ein Kind zu haben. Wir tendieren dazu, entweder mehr auf Karriere oder mehr auf Beziehung zu setzen. Aber solche Abstriche müssen nicht sein. Beides geht.

Der wichtigste befreiende Schlag für beide Geschlechter ist, sich nicht dem verbietenden Gewissen zu unterwerfen. Wer die Einstellung zu seinem Gewissen angreift, schafft Raum für beides, den aktiven und den passiven Wunsch, und scheut weniger, andern klar zu sagen, was man denkt, bleibt offen und aufnahmefähig. Die Psychoanalyse kann einen Raum anbieten, der die Tat (die damalige und die künftige) erlaubt und den frühen libidinösen Wünschen Platz verschafft.

«I would like to show that between architectural orders and building materials is no direct continuity. And a science that might explain the proper reason of matter has yet to be born.»

ON THE INNER TENSION OF MATTER

Andrea Alberto Dutto

Andrea Alberto Dutto, born 1985, has been appointed as adjunct professor in Architectural Design at the Politecnico di Torino (Italy) in 2019. In 2010, he graduated with a dual degree in Architecture at the Ecole Supérieure Nationale d'Architecture de Marseille and the Politecnico di Torino. He achieved the title of Ph.D. and Doktor der Ingenieurwissenschaften at the RWTH Aachen in joint agreement with the Politecnico di Torino in 2017.

We are in 1633 in the villa «il Gioiello» on the hills of Arcetri, a small town near Florence. Galileo Galilei is here in exile and despite his blindness, he carries on a research begun in the years of his stay in Padua. Although not documented by historical sources, Teofilo Gallacini, physician and author of a book entitled «On the mistakes of architects" can be acknowledged as a visitor at the Villa. This meeting might have prefigured the last famous book by Galilei «Discourses and Mathematical Demonstrations Relating to Two New Sciences». Gallacini is a scientist but his opinion on architecture is heavily influenced by the theory of proportions rooted in the Renaissance. Conversely, Galileo is not directly involved in architecture, but his experiments on the elements of construction open up a discussion that undermines the principles of the theory of proportions. The dialogue between Galileo and Gallacini intercepts some themes and methods of experimental science which emerge during the seventeenth century and which gradually exhaust the techniques of building rooted in humanistic metaphysics.

Teofilo Gallacini
... Man is too weak to reach the truth with the sole strength of his Reason! Cardinal Bellarmino would have come to this conclusion without asking you to defend the Copernican thesis by traveling to the sun and back, but simply by observing St. Peter's vault. Viewed from below, the barrel vault that Michelangelo designed as a semi-circle does not display the perfection one would expect, as it is compromised by the protrusion of the cornice at its base. As I have shown in my book, even the highest expression of reason can fail in the face of experience.

Galileo Galilei
The mistake you mention may provoke disapproval. However, I'd like to draw your attention to far more serious mistakes such as breakages and failures in buildings. Illustrious treatise authors described these faults but avoided explaining the reasons behind them...

Teofilo
Do you mean to say these errors are produced by a defect of human reason?

Galileo
No! Quite the contrary, I'd say these phenomena are caused by an excess of human presumption! Treatise writers have argued that utilitas, venustas and firmitas are sons of a single father who, ultimately, is Man with proportions made in the image of God. Hence, the theory of proportions came to represent the true foundation of Architecture by the means of the five orders of the column which provided both the artistic and structural foundation of architecture at once. And yet, we have evidence that even a beautiful building designed in full respect of these proportions can prove yielding when built.

Teofilo
So, you believe that venustas can exist without firmitas? That a building can be magnificent even though it displays poor strength...? As I have shown in my treatise, Architecture is the imitation of Nature which is perfect in all its parts, as a whole. Therefore, if a part of the building appears defective, the whole building will appear defective as well...

Galileo
With my objection I don't want to put at stake architecture as art. Rather, I focus only on its construction. We have no clear evidence that there is continuity between the principles of art and construction. As you wanted to show before with your criticism of St. Peter's vault: between experience and design there is no necessary correspondence; what is perfect in design can be imperfect in proof of experience. Similarly, I would like to show that between architectural orders and building materials there is no direct continuity. At least, we have no scientific proof of this relationship so far. And a science that might explain the proper reason of matter has yet to be born.

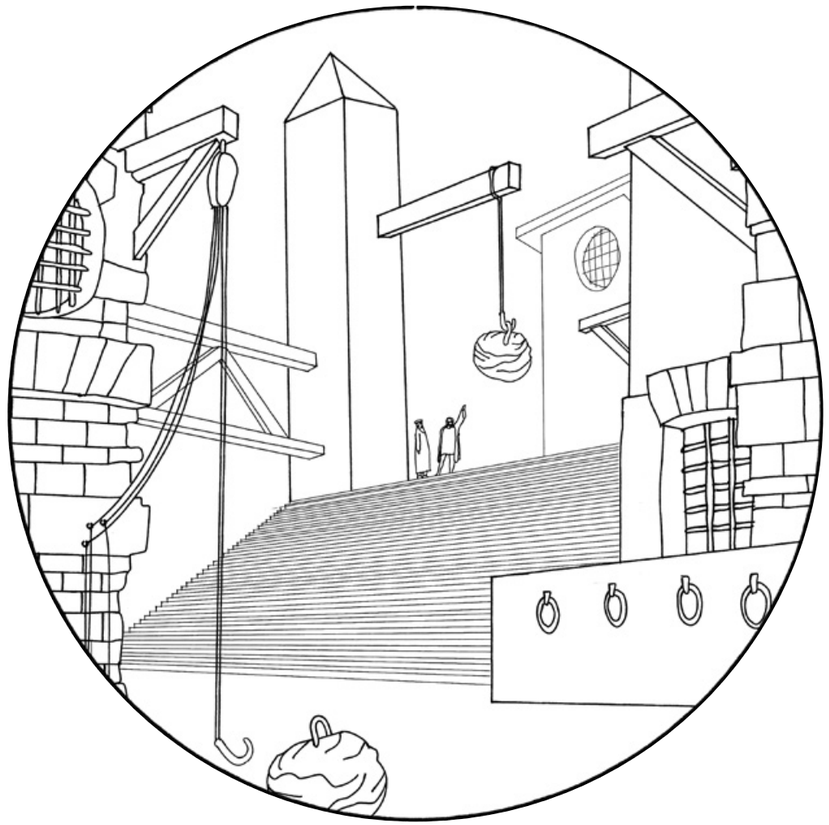
Teofilo
Do you want to say that mute and inert matter can achieve its own reason and overcome its ignorance? Would you make the miracle that God was well aware of doing, namely, providing matter with the same privilege of man's reason?

Galileo
No! Because this would mean to anthropomorphize matter. Transforming Nature into the likeness of man would be an umpteenth act of arrogance over creation. And this illusion has no limit whatsoever as it is witnessed by the architectural treatises. They argued that man's proportions are the fundamental measurements of a grid that extends and rules the whole universe. Thus, they have deceived man himself about the possibility to transfigure matter in his own image.

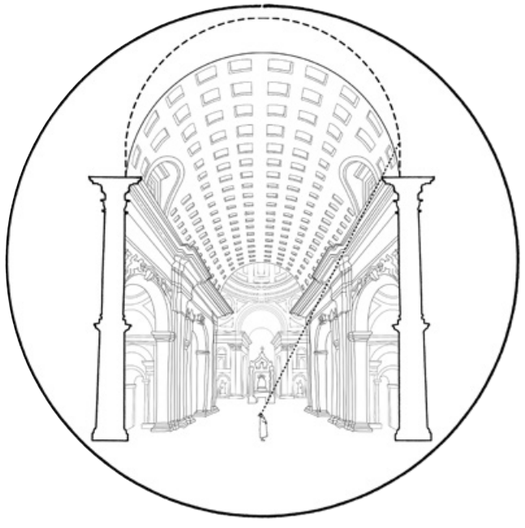
Teofilo
Yet, if instead of taking man as a model, with his beautiful and harmonious proportions, they had adopted formless matter, what monstrosity would have resulted?

Galileo
As I said, I don't want to question the rules of architecture as art! What I say is that these rules cannot be put at the foundation of the science of building. To reduce everything to a single metaphysical principle, able to reconcile such different things as the robustness of a beam with astronomical phenomena, is simply senseless. And even if such a unique and perfect principle was possible, it is the urgency of unexpected buildings' collapses that requires the advent of a new science which, albeit provisional, can show the real causes of these phenomena and how to prevent them.

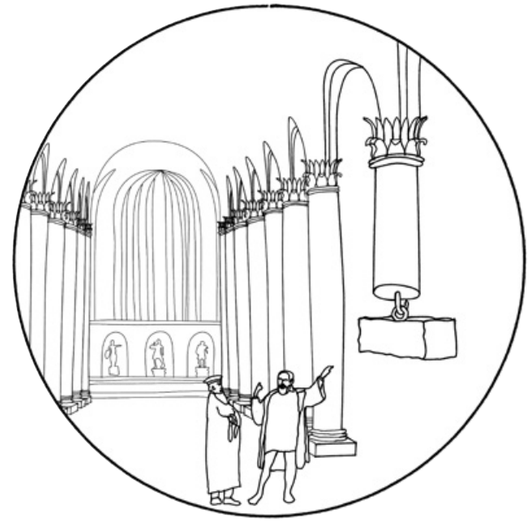
Teofilo
And yet, treatises already provide techniques to prevent the most common building failures. For example, the illustrious Andrea Palladio proposes valid recipes for careful builders... and in my own treatise on mistakes in Architecture, I propose many other recipes related to the execution and maintenance of buildings.



Andrea A. Dutto, *Allegory of the force in the beam* (2019)



Andrea A. Dutto, *The imperfection of St.Peter vault at the proof of vision* (2019)



Andrea A. Dutto, *Allegory of the force in the column* (2019)

Galileo

Yes, they may provide recipes, but none of them proves to have knowledge of the causes! Faced with the unknown tragedy of a breakage and encouraged by their own wisdom, they simply decreed that matter is imperfect. As if to say: if the architrave shows signs of breakage but its proportions are perfect, this is due to materials that are imperfect and such imperfection is not domain of reason.

Teofilo

However, the architrave's imperfection may be caused, not simply by matter, but by the defect of other parts of the building. As shown by Vincenzo Scamozzi, there may be failures in the foundations that invisibly propagate in the building until they are finally noticed once they reach the top of the walls...

Galileo

Well, following this acute intuition, I propose another observation that, to a certain extent, proves that the theory of proportions is flawed. Even when abstracting from all the imperfections of matter and respecting the proportions of architectural orders, buildings can still be defective. What I mean is that, due to the mere fact of having a weight, between two buildings of equal proportions but different sizes, the bigger one is more fragile than the other.

Teofilo

I will refute your thesis with a simple proof ... The wonderful buildings that have been handed down to us by our predecessors, result from models of much smaller size, but of equal proportions. Moreover, Leon Battista Alberti states that the model is the most appropriate tool to foresee those issues occurring in the making of buildings...

Galileo

Alberti forgot, however, the advice of his most illustrious predecessor. Arguing about machines, Vitruvius recommends distrusting models because they are only apparently reliable but often source of deception. Then, at the time of the Goths the extremely complex vaulted systems employed in the making of gothic cathedrals inevitably ended up in spreading the use of downscaled models among builders. And yet, if these models had faithfully foreshadowed buildings' behaviour, then we would not have notice of the numerous collapses that followed. Therefore, instead of models, I'd argue that the new science of construction should rather employ the language of mathematics that can precisely predict the behaviour of matter.

Teofilo

But you still avoid refuting the proof I brought in support of Alberti! How do you explain then that there are numerous examples of buildings designed on the sole basis of models that are still good examples?

Galileo

I don't want to deny that the examples you are referring to can still serve as an ideal for the art of architecture. But they do not offer a scientific explanation of the solidity of buildings and their failure can prove extremely harmful. Indeed, I must premise that, the new science I propose will not only benefit the builders but also the financier. By having an exact knowledge of the relationship between matter and form, all materials which are in excess of the load-bearing requirements of the building can be removed and such detriment might result as remedy to annoying gigantism. I will therefore follow Alberti's advice: my building will be cheaper. Unlike him, however, I will not use metaphysical arguments, but logical demonstrations drawn from the observation of physical phenomena...

Teofilo

...However, if your demonstration will simply result in the lowering of building costs you will not have done good service to architects, nor to Architecture. Perhaps, who will benefit from your scientific work will be the financier of the building but not its architect...

Galileo

Indeed, it is likely that neither of the two will get the real advantage! Because whoever will benefit from this new science has yet to be born. And his language will be neither ordinary nor metaphysical. He will express himself with the exact language of mathematics. And there will be no reason to doubt his work because his knowledge will be based on statements that are the result of the observation of matter as well as the evaluation of those invisible agents of which too little is known and which I call ‹forces›.

Teofilo

But if you say that your science does not speak a common language, how will you communicate your science to others who, like me, but still less knowledgeable, are involved in building?

Galileo

Without the need of mathematical proofs, I can explain the mechanical principles of building with the sole aid of common words but without whatever sort of metaphysics. As I already stated in relation to models, whose fallacy results from the theory of proportions. In fact, this theory states that objects of different size and same proportions are equally resistant. However, it does not consider that between weight and surface there is no one-to-one correspondence. Suppose we take a die with a side equal to 2 fingers. Its surface will be equal to 24 square fingers. If divided into 8 smaller dice of equal proportions, each of them will have a surface of 6 square fingers, equal to the fourth part of the surface of the original dice. But its weight will not be a quarter but an eighth of the initial one.

Teofilo

So, if the building increases its size proportionally, its weight increases as well, and it's only by turning itself into a lighter material that it would preserve the robustness of the initial model...

Galileo

The theory of proportions holds that buildings of different sizes and equal proportions are equally resistant. On the contrary, physical proofs show that internal resistance varies in relation to size. The weight does not keep linear relationship with the building proportions but, indeed, it dramatically increases! Therefore, between two buildings of equal proportions and same materials, but of different sizes, the weight determines the weakness of the larger one. And in order to avoid breakages, it is necessary that proportions change together with size or that the building becomes miraculously lighter while upsized...

Teofilo

Certainly, this is an interesting test for physics, but it is completely irrelevant for the practical purposes of Architecture! Which building can be conceived as a model of stone and, finally, materialized as a thin veil of parchment?

Galileo

Well, your doubt is due to your stubbornness to assume the building as a whole. Since it is widely known that buildings require the assemblage of elements, I thought I could bear my experiments on the most elementary ones, namely the column and the beam. By observations I came to the conclusion that the elements of construction, depending on their shape, react differently to the strain of forces but it is the material they are made of that eventually establishes their behaviour...

Teofilo

Hence yours is not really a science of buildings but rather a science of the elements of building?

Galileo

As I said, I started by observing the simple elements of building in order to achieve those principles from which I could make a step further towards the science of construction. Unlike treatises that begin with the perfect form, I focus on matter. With my experiments on the column I have come to show that matter admits a maximum load beyond which it loses its integrity. By applying a load along the axis of the column, in the opposite direction to its anchorage, I recorded the variation of load which in different materials generates the breaking of fibers. Then, I have come to establish that different materials have different resistance values which are given once and for all, and are therefore absolute, that is to say independent of appearing in one form or another.

Teofilo

I'm sorry but I still don't understand the practical purpose of all this... It is in fact known that columns can break due to weights... But it is very rare or non-existent the possibility that this might happen because of loads arranged along the axis. On the other hand, a frequent case scenario concerns loads coming from the side of the column, causing its unbalance until it rotates around the base and breaks on the ground.

Galileo

What you mention, however, is a problem of stability rather than resistance. What I mean is that stability can be compromised by external forces which might cause imbalance. But resistance comes only afterwards, since different materials react in different ways to the impact at the ground... some will disintegrate while others will only be scratched. And we can predict such behaviours through mathematical calculation. More precisely with this example I observed a second feature of matter through experiments I made on a beam stuck in the wall. Similar to the resistance tests I did on the column, I placed a load at the opposite side of the fulcrum, so that its distance coincided with the length of the beam. I have therefore noticed that, this time, the breaking weight does not coincide with the absolute resistance of the material. Rather, it appears to be relative to the length and thickness of the beam, therefore its resistance is commensurate to a specific shape...

Teofilo

So, what you want to say with your experiments is that there is no absolute geometry that changes its properties without changing its size? Therefore, due to the mere fact of depending on the properties of the material, Architecture is subject to rules that are not those of the architectural orders but rather the related to mechanics ...

Galileo

Your obstinacy in speaking of Architecture with a capital A, almost like finding a source of consolation in it, pushed me to affirm, with ever greater courage, that the science I have in mind is incompatible with that of the treatise writers. It is the science of shapelessness... It does not find its foundation in the principles that provide forms to buildings, but rather in the invisible forces that deform them. And if architecture might establish such a science as its foundation, rather than a metaphysics, it will inevitably have to accept that divine proportions are as imperfect as matter is. Just as a man of gigantic stature should have, in order to be equally strong, a bone structure that is not proportionate to that of a man of normal stature, but completely deformed, a building of variable proportions, will have to accept deformation with respect to its model. Because this deformation is not an imperfection of reason but rather an expression of the rational development of natural laws.