On Mathematics, Mechanics and Architecture

The integration of architectural- and structural design

Pieter de Jong

Research problem

Architectecture is the discipline that deals with the design and construction of buildings. As regards design a distinction is being made between architectural and structural design. Architectural design is concerned with the form, and structural design with the strength, stiffness and stability of buildings. During the past centuries both ways have evolved into separate professional disciplines. A recurring problem is that both professional disciplines don't really understand each other, where needed. This research will go deeper into subject of the more fundamental causes which prevent the integration of these professional disciplines. For this purpose the technological background of the professional disciplines, which should be the common basis for the professional languages, will be further investigated. Technology is the sum of the knowledge of the means and methods of the industry and the applied sciences. As applied science technology is dependent on mathematics. Mathematics, however, knows ruptures and sharp contrasts. 'Analysis' (the calculus and related subjects), for example, embraces all the developments based on limits while analytical geometry involves no limit processes, and the ∞ of 'analysis' can't be compared with any number while in geometry the line at infinity is on the same footing as any other line. The proposition is that the incorrespondence of 'analysis' and geometry is not a given thing, but that 'analysis' and geometry are conflicting in this way. That is a matter of mathematics, but besides that also a matter of architecture. Over the centuries architects have made important contributions to the development of descriptive- and projective geometry, and to analysis. The architects Brunelleschi and Alberti discovered the rules of perspective, the architect Desargues founded projective geometry, and the civil engineer, then also structural designer, Cauchy founded the calculus on the concept of the limit. Through mathematics architectural design became a science in the Renaissance, and through structural design architecture eventually became a discipline at the technical universities. The conflicting approaches of 'analysis' and geometry in mathematics form an obstacle for the integration of the professional disciplines in architecture, for the structural designer has to work with the calculus and the architectural designer is dependent on geometry. In addition to that the structural designer, when he needs geometry, uses a Cartesian coordinate system. In common Cartesian geometry however there is no infinite and no imaginary, which is a main cause of the aversions of the architects against 'the exact sciences from which the role of intuition and imagination has been eliminated', and the oppositions between the professional disciplines. In his philosophy, and in the architecture of the house he designed Ludwig Wittgenstein showed the insolubility of the problem of the infinite within the framework of present science.

Research aim

The aim of this research is to sketch the outlines of a mathematical theoretical framework which allows the integration of form and structure in architecture. To achieve this a new concept of infinity will be introduced, which unites analysis and geometry in an analytic geometry. The

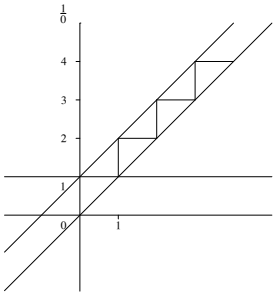

Figure 1: $\frac{1}{0} = 1 + 1 + 1 + 1 + \cdots + \frac{1}{0}$

split between the professional disciplines, due to the different mathematical approaches, thus disappears to be replaced by a distinction solely based on the difference between mathematics and mechanics. In mechanics time is an extra variable, and mass an extra factor. In principle mathematics is the design instrument of the architectural designer, and mechanics the design instrument of the structural designer.

Figure 2: Pillar from a synagogue in Chorazin, 3-4th century A.D.

Scientific context

The research in this form is being legitimated by Vitruvius who left open the possibility of transcending the architectural discipline by means of a thorough knowledge of mathematics, and to take up an own position in it. As regards the history of art and architecture the research may be situated near Rudolf Wittkower (*Architectural Principles in the Age of Humanism, Gothic versus classic*), Erwin Panofsky (*Idea, Perspectief als Symbolische Vorm*) and Manfredo Tafuri (*Discordant Harmony from Alberti to Zuccari*), and as regards mathematics near L. Euler (*Einleitung in die Analysis des Unendlichen, Foundations of Differential Calculus*), G.H. Hardy (*What is geometry?, Mathematical Proof*), D.H. Fowler (*The Mathematics of Plato's Academy*). As far as philosophy is concerned the works of Immanuel Kant (*Gedanken von der wahren Schätzung der lebendigen Kräfte, Kritik der reinen Vernunft, Prolegomena*) are relevant, and the philosophical debate at the beginning of the twentieth century.