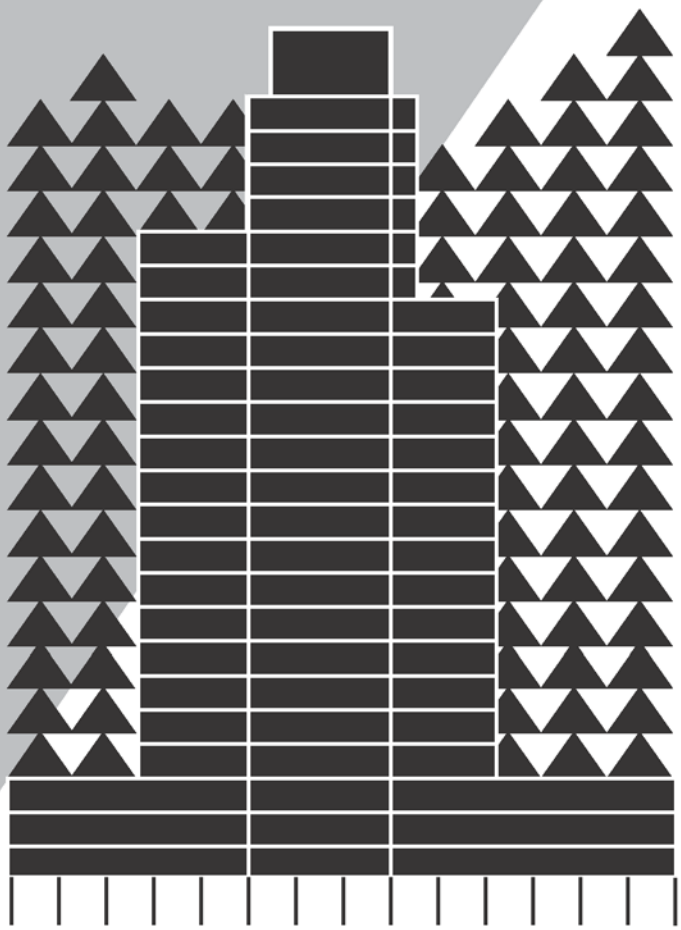
NEXUS 2021

Architecture and Mathematics

Conference Book



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STAIRS LIKE WALKING ON A SMOOTH HILL

Werner Bäumler,[1] ***Cornelie Leopold***[2]

Introduction

There had been several rules for designing stairs in the history of architecture. One important rule, still used today, goes back to François Blondel. He developed a formula for the stairs design considering the human step length. Werner Bäumler – Laurin developed in the 1990s the idea to create a stairway which corresponds walking up and down a smooth natural hill by introducing a transition from the horizontal plane to a slight rise and again a transition to the horizontal plane when arriving on a higher level going up the stairs. These reflections led to the idea to design a stairway following the gradients of a sinus curve. The drawings for developing the idea by Werner Bäumler will be presented. A graphical method to design sinus stairs according the rules for defined architectural situations will be shown additionally. Models and a walk-in installation will enable to comprehend and experience the design concept of the sinus stairs.

The Research

Going back in the history of architecture to look for rules for stairs, we can find important contributions by Vitruvius, Alberti, and Palladio. Then we come up with the book *Cours d'architecture* by the French architect and engineer François Blondel, 1675. Blondel introduced in Book 3 a formula for the measurements of stairs, based on measures of the human step. He postulated that two rises and one tread should make together the length of 65 cm. The step measurement rule is the most important planning principle for stairs design till today. It is based on the insight that the human step length on slopes is reduced by twice the height, therefore two rises. The German building conservator and stairs researcher established in the 1990s Scalalogy as the science of stairs. He developed a stairway typology in his book *Handbuch der Treppenkunde*, collected and analyzed numerous examples as well as details of stairs. Mielke also took into account empirical studies on human movements on stairs. He criticized that fixed traditional rules are used for designing and building stairs instead of empirical studies on using stairs. One result by studying stepping paths on stairs was for instance that in most cases, people do not choose the direct ascending or descending line with constant slope ratio. Therefore, the user of a stairway does not demand for a constant slope.

Werner Bäumler noticed another problem in stairs designs: the irritation of the step at the beginning and ending of stairs. He documented in sketches and notes around 1991 (Fig. 1), that there is a problem of transition from the horizontal plane to the stairs and to the horizontal plane again.

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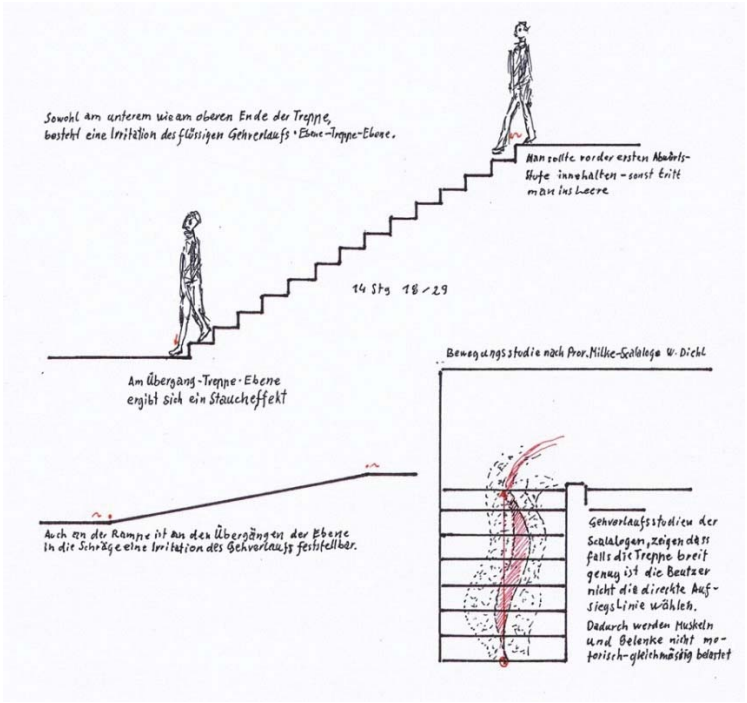

Fig. 1. Irritations by transition from the horizontal plane to the stairs and to the horizontal plane again. Stepping paths studies according Friedrich Mielke.
Sketches and notes © Werner Bäumler – Laurin

The wish arose to design a stairway with a fluid course like walking up and down a smooth hill. This brought him to the idea to take the sinus curve instead of a straight line for the inclinations in the stairs design. Following the sinus curve, we get changing inclinations and therefore a stairway with varying inclinations. A consequence is, that each step has another rise. But to receive a fluid walking, the formula of Blondel should be followed at the same time, so that the user of the staircase can walk with a fixed step length preventing stumbling. These two conditions led to the sinus stairs concept with increasing then decreasing risers and decreasing treads then increasing treads to achieve a constant step length (Fig. 2). Several sinus stairs designs had been created in drawings and models, before the first example had been built in 1991 in front of the Bauhaus in Dessau (Fig. 3).

Stairs as element of architecture had been part of the exhibition “Elements of Architecture” at the Architecture Biennale in Venice 2014, curated by Rem Koolhaas. Many models and books of Friedrich Mielke had been shown in the central pavilion, and also a kind of sinus stairs had been built up. But this version did not follow the described concept of Werner Bäumler. Friedrich Mielke modified there the sinus stairs concept by using increasing and decreasing risers, but with treads remaining at a constant depth. Then Blondel’s formula is not fulfilled. This changed concept results in changing slopes and changing step lengths, when walking on the stairway. There had been no fluid walking on the stairs in the exhibition. It had been an irritation, an experience of stumbling. In the publication “Element of Architecture.

Stair", catalogue accompanying the Biennale in Venice 2014, a text by Mielke from 1992 had been published, where he argued to modify the idea of Laurin:

> However, once the tread is of sufficient depth, and in order to achieve the stair user stepping pro- and regressively, without falling into a potentially endangering monotony, it is appropriate to modify Bäumler's idea. A first variant is proposed by the Centre of Stair Research. It maintains all treads of one flight at the same depth. This, combined with differential riser heights, results in challenging the stair user with changing lengths of step, which activates their reactions (Trüby et. al. 2014; Mielke 1992).

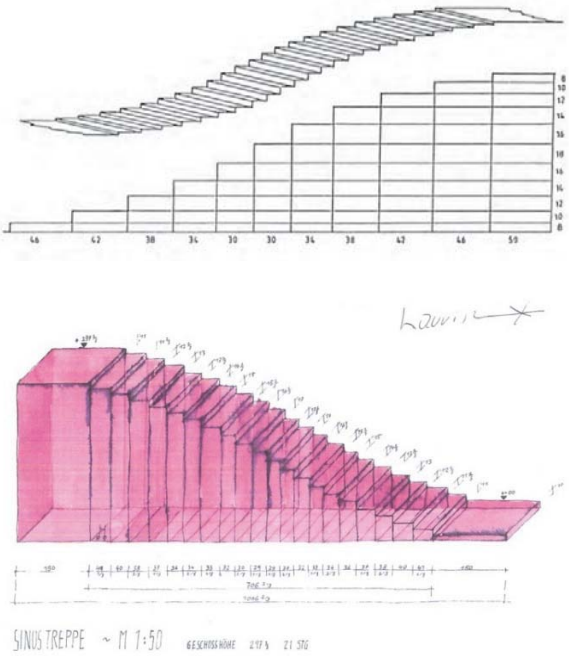

Fig. 2. Sinus stairs concept with increasing then decreasing risers and decreasing treads then in-creasing treads to achieve a constant step length. © Werner Bäumler – Laurin

Fig. 3. Laurin's Sinus Stairs in front of Bauhaus Dessau, 1991. © Werner Bäumler – Laurin

These backgrounds and experiences had been the basis for a student building project for walking on a sinus staircase in a real architectural situation. Students of architecture studied the concept and developed a graphical method to define the sinus stairs for a given situation with its parameters (Fig. 4).

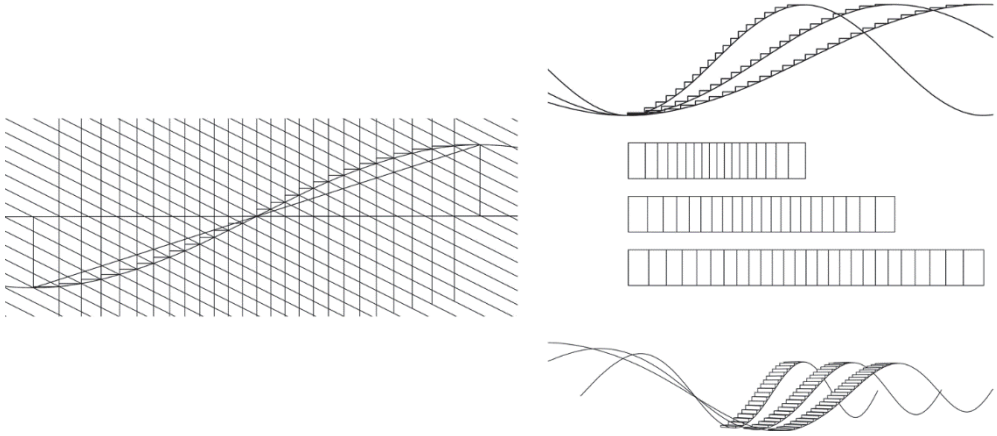

Fig. 4. Graphical method with results of variants of sinus stairs by students of architecture, Moritz Brucker and Benedikt Blumenröder

The resulted sinus stairs version had been transposed in a concrete model by the students. Many other variants are possible according the same concept. Werner Bäumler created several variants in drawings and models (Fig. 5). In 1994 the first use stairway had been realized in an office and administration building in Landshut, Germany according Laurin's sinus stairs concept (Fig. 6).

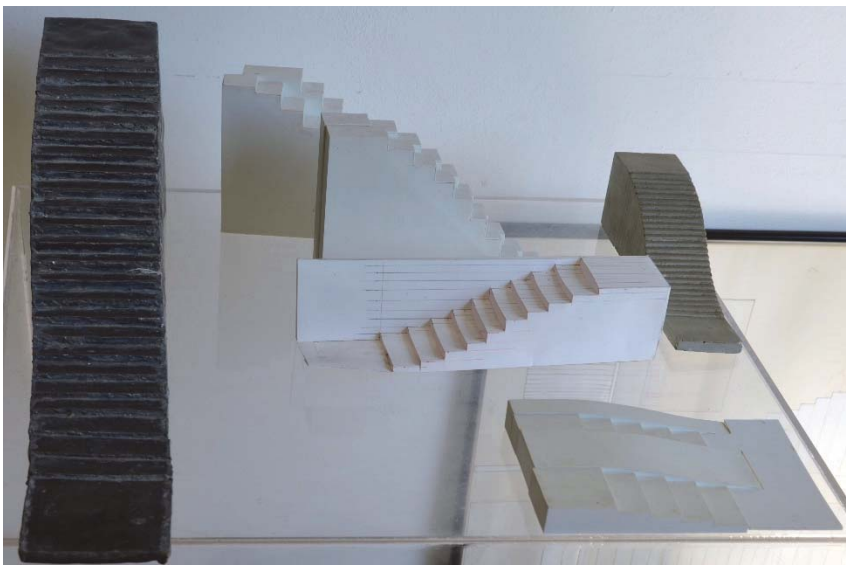

Fig. 5. Models of the sinus stairs

Fig. 6. First use of stairway, 1994, in the office and administration building Wolf in Landshut, Germany, by Werner Bäumler – Laurin, photo by Toni Ott

Fig. 7. Installation of the walk-in sinus stairway in the faculty building, 2018. Views from below, from the side and from above

The entrance hall of the faculty building had been chosen for realizing the sinus stairs project. The students decided to build the sinus stairs from the entrance level to the first platform on one part of the width of the existing staircase out of wood (Fig. 7). Wood of an old staircase could be used for the treads and cut out of blockboard panels for the stringers. Walking on normal stairs was directly comparable with walking on sinus stairs side by side through this concept. Finally, the users of the sinus stairs confirmed the smooth and fluid walking on the sinus stairs.

Conclusion

The idea to design a staircase enabling walking like climbing up and down a natural smooth hill led to the concept using the sinus curve for the changing inclinations of the stairs. It turned out as an interesting approach to bring together studies of human movements with the studies of the sinus curve for developing a new concept for a staircase. After designing the sinus stairs, it remained doubtful if the concept is successful to achieve a comfortable walking. Therefore, only a walk-in experiment could confirm the effect of the design. The built sinus stairway on the entrance stairs of the faculty building gave the chance for experiencing the difference between the normal and the sinus stairs. The sinus stairs contradict the actually valid stairs rules, but it would be worth thinking on expanding those rules according this concept.

References

Bäumler, W. Laurin. Homepage, http://www.laurinonline.de/installationen.en.html, last access 21 April 2021.

Blondel, F. 1698. *Cours d'architecture. Cinquième Partie, Livre Troisième, Des Escaliers* (Enseigné dans L'Academie Royale D'Architecture, Paris, 1698). http://digi.ub.uni-heidelberg.de/diglit/blondel1698c/0335, last access 01/02/2021.

Leopold, C., ed. 2018. *Scalalogie*. Kaiserslautern: Technische Universität Kaiserslautern,.

Leopold, C. 2019. Geometric Aspects of Scalalogy, *Journal for Geometry and Graphics* 23 (2): 221-233.

Mielke, F., ed. 1992. Collectaneen 3. Scalalogia. *Schriften zur internationalen Treppenforschung*, Band VI, 88-91. Allersberg_ Jacob-Gilardi-Verlag.

Mielke, F. 1993. *Handbuch der Treppenkunde*. Hannover: Verlag Th. Schäfer.

Mielke, F. 2007. Treppen im Modell. *Schriften zur internationalen Treppenforschung*, Band XIV, 18-21. Edelshausen: Verlag Klaus Hupfauf.

Mielke, F. 2008. Mensch und Treppe. Scalalogia. *Schriften zur internationalen Treppenforschung*, Band XVI. Potsdam: Knotenpunkt Verlag.

Trüby, S., Koolhaas, R., Boom, I., Friedrich-Mielke-Institut für Scalalogie. 2014. *Elements of architecture 14. International Architecture Exhibition, la Biennale di Venezia*: *Stair*, 194-195. Venice: Marsilio.

Wiget, C. 1992. Treppe mit weichem Übergang. *Hochparterre: Zeitschrift für Architektur und Design* 5(1-2): 69.