steam shapes

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Can steam bending of wood be applied at the scale of architecture? This question arose early in my research, after finding bent hardwood vessels created by my grandfather in my uncle's workshop. Bending wood has a rich tradition in furniture and object design, celebrated for its formal expression and ergonomic qualities. However, despite its remarkable flexibility, steam bending has seen limited implementation in architecture. The goal of this experimental thesis is to explore the potential of steam bending on an architectural scale. Potential exists not only in the expressive qualities of a steam-bent timber structure, but also in its material efficiency, as well as environmental and structural advantages.

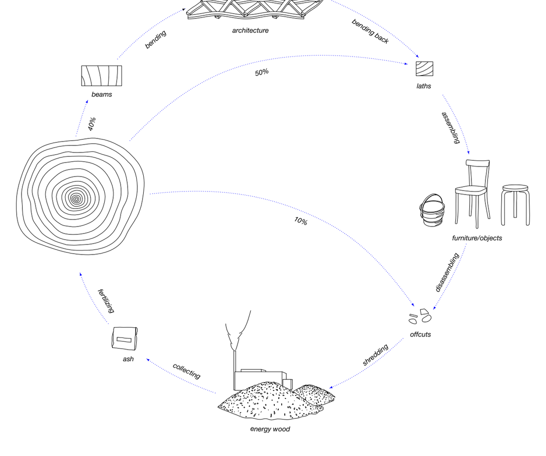
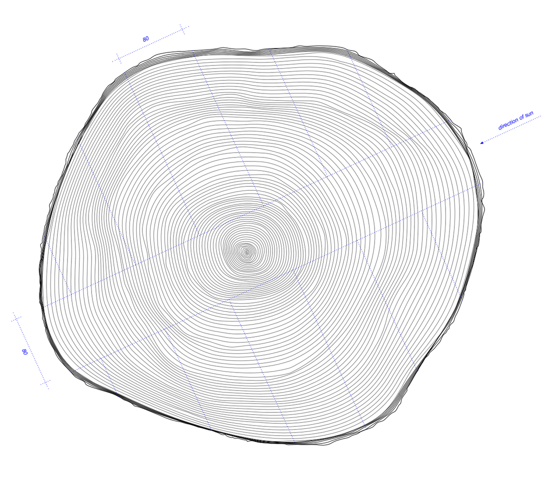
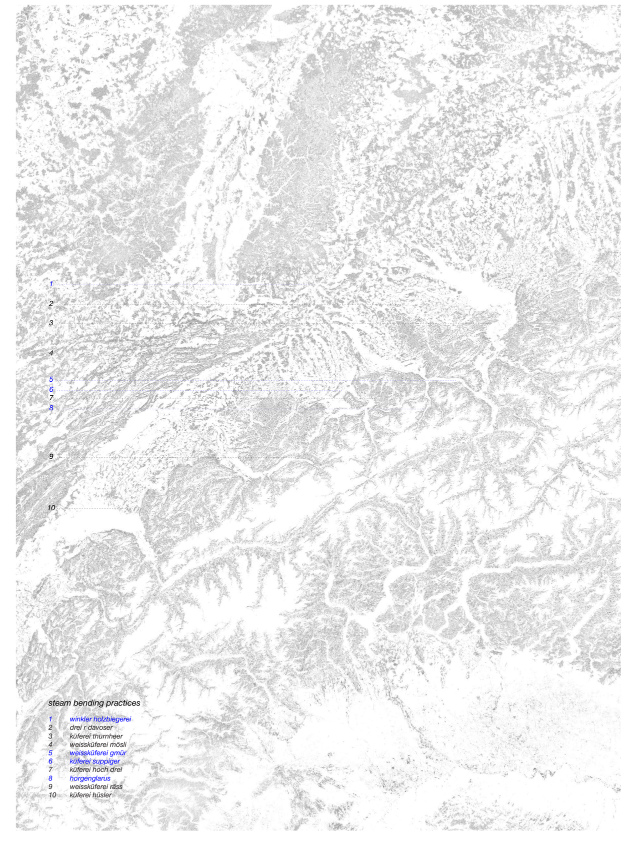
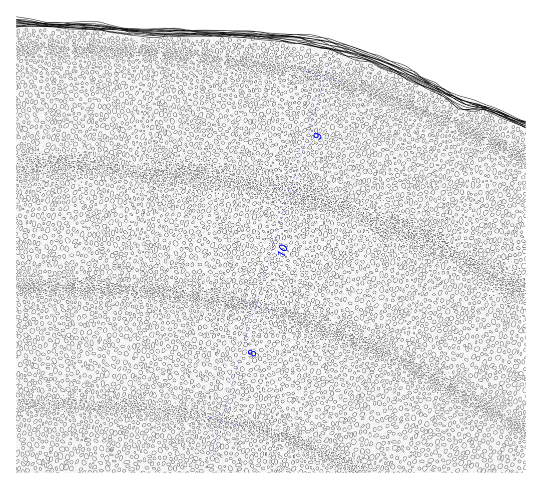
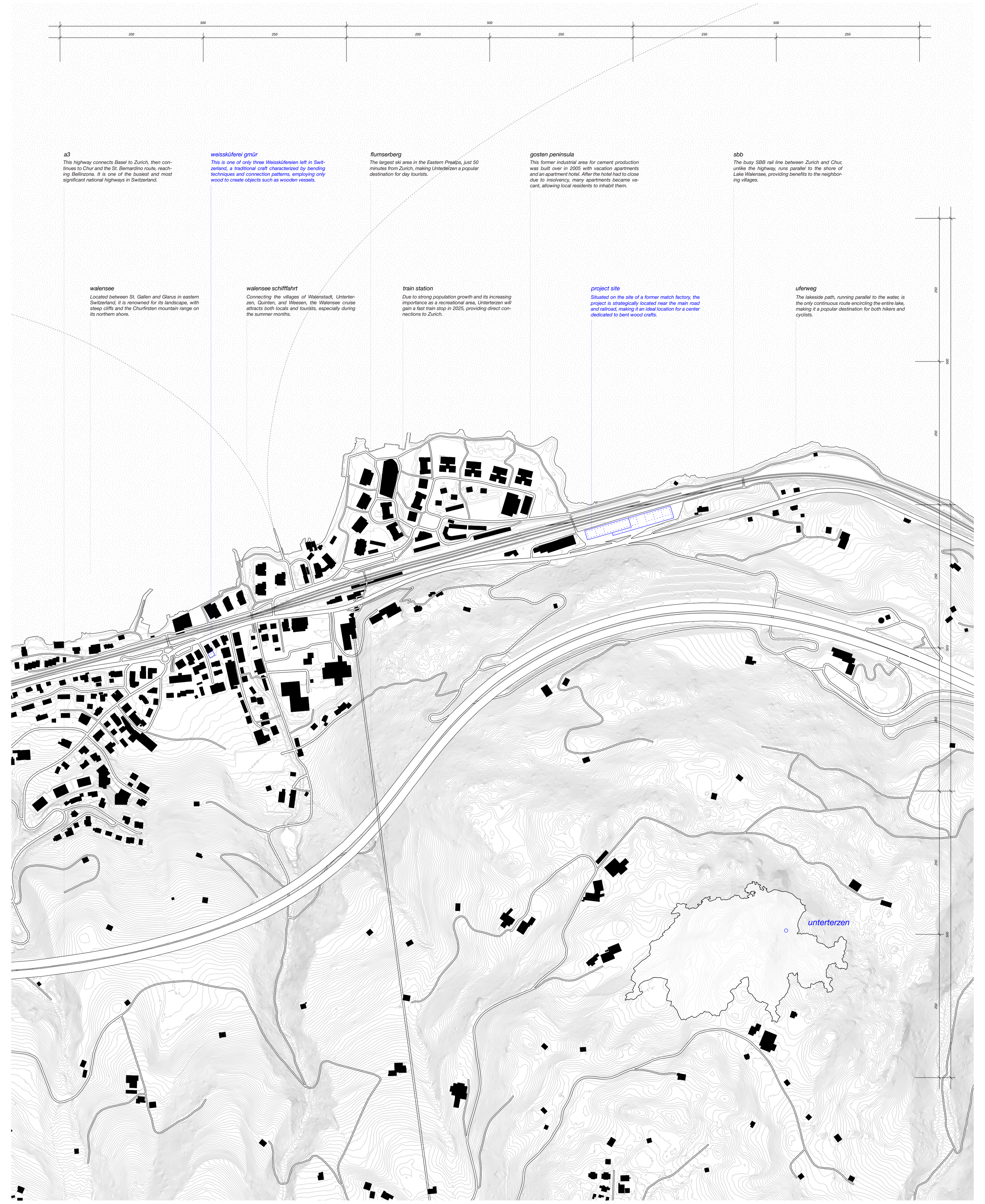
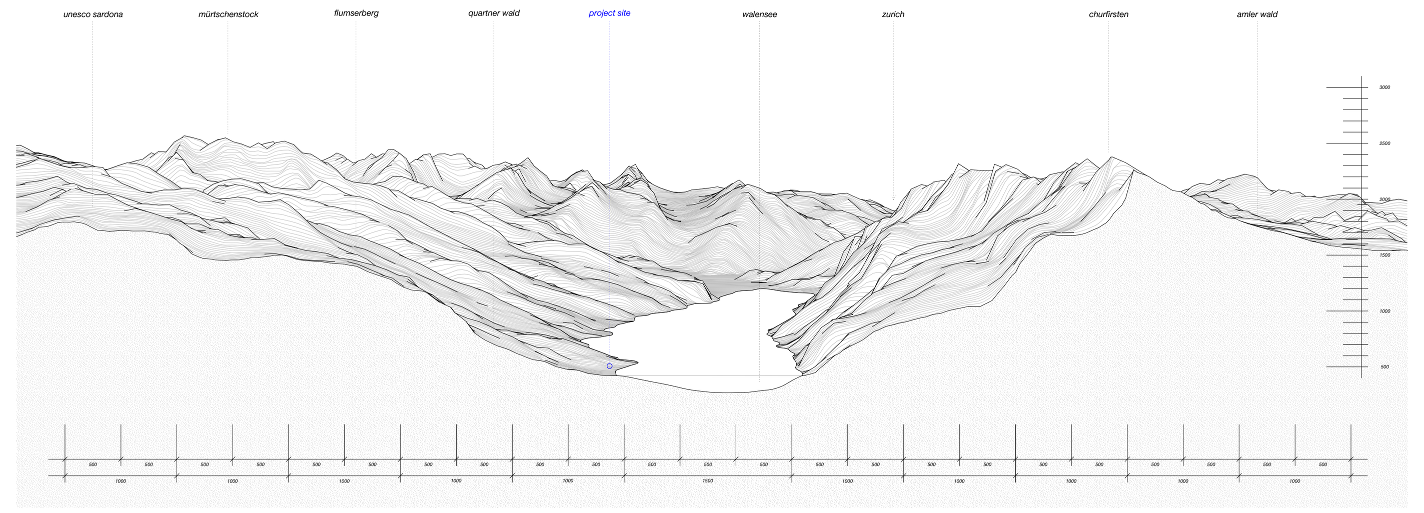
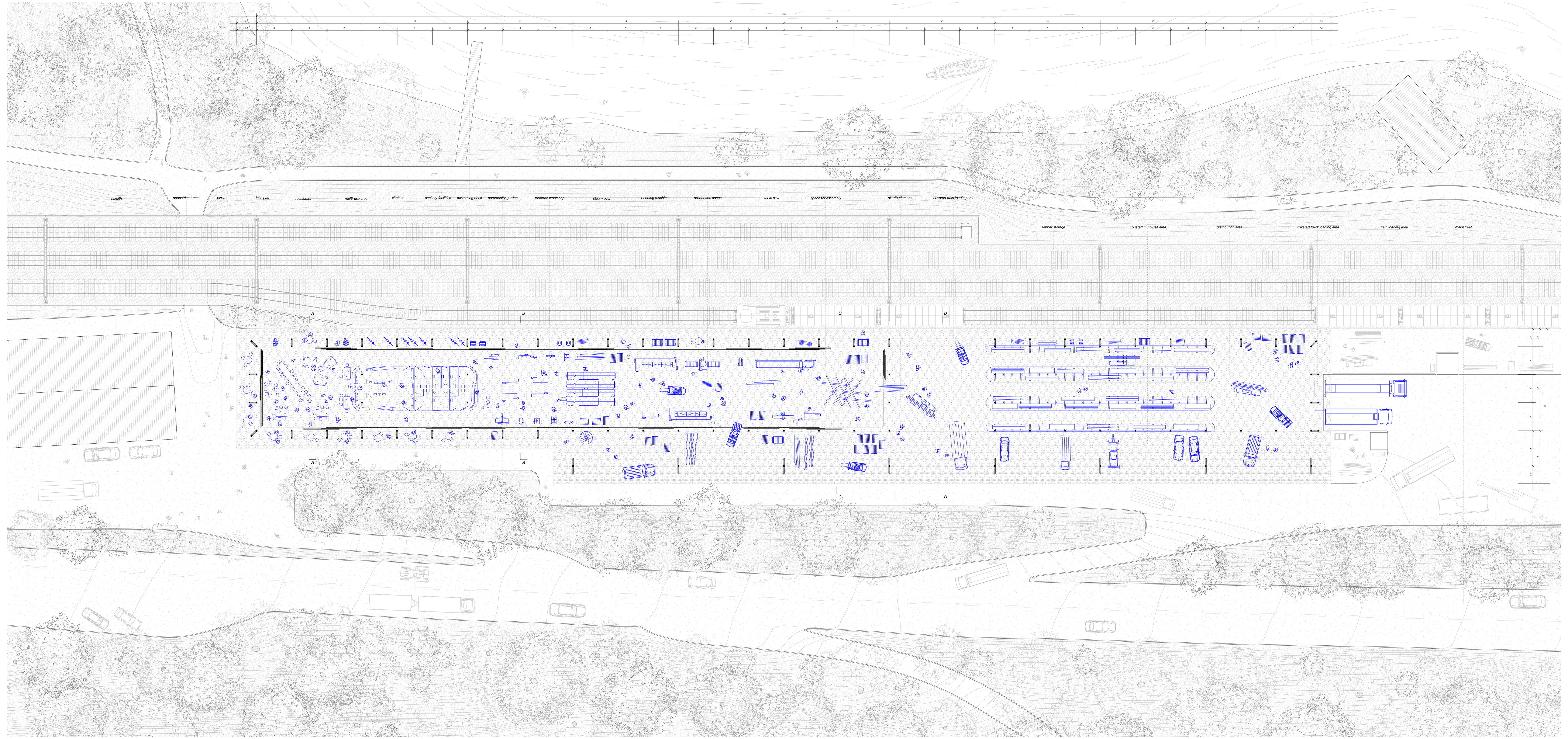
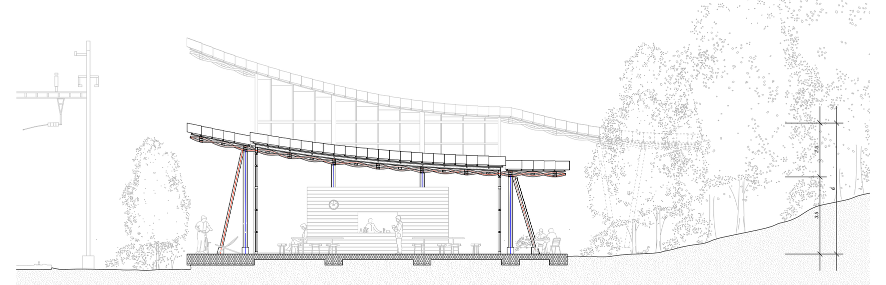
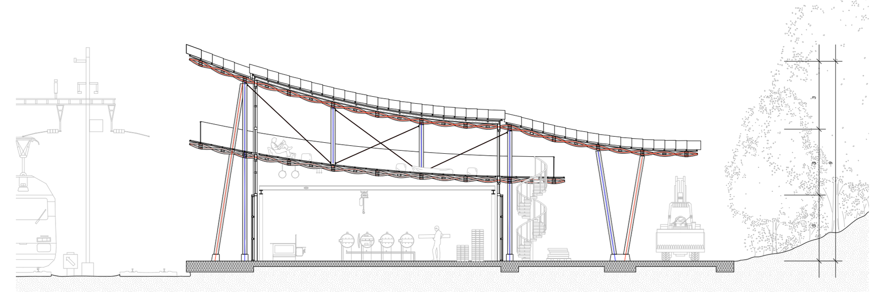
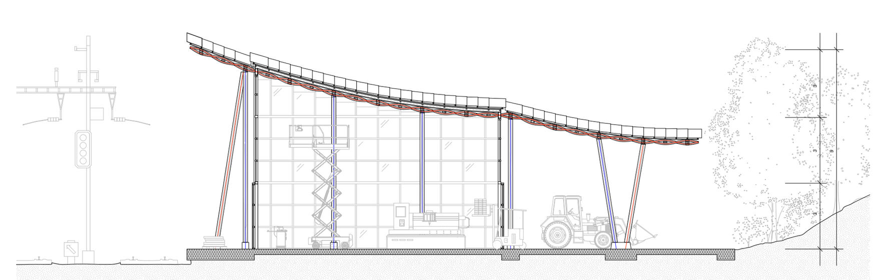
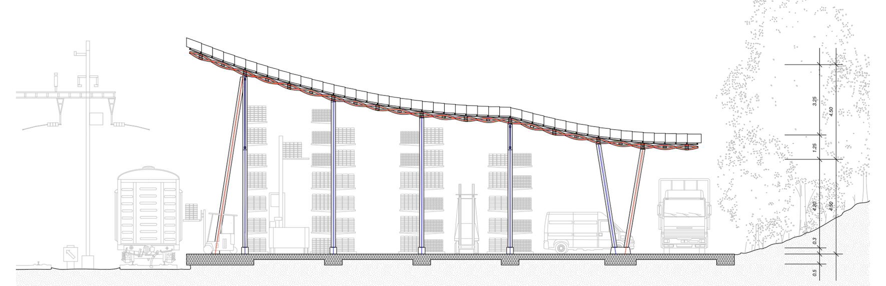
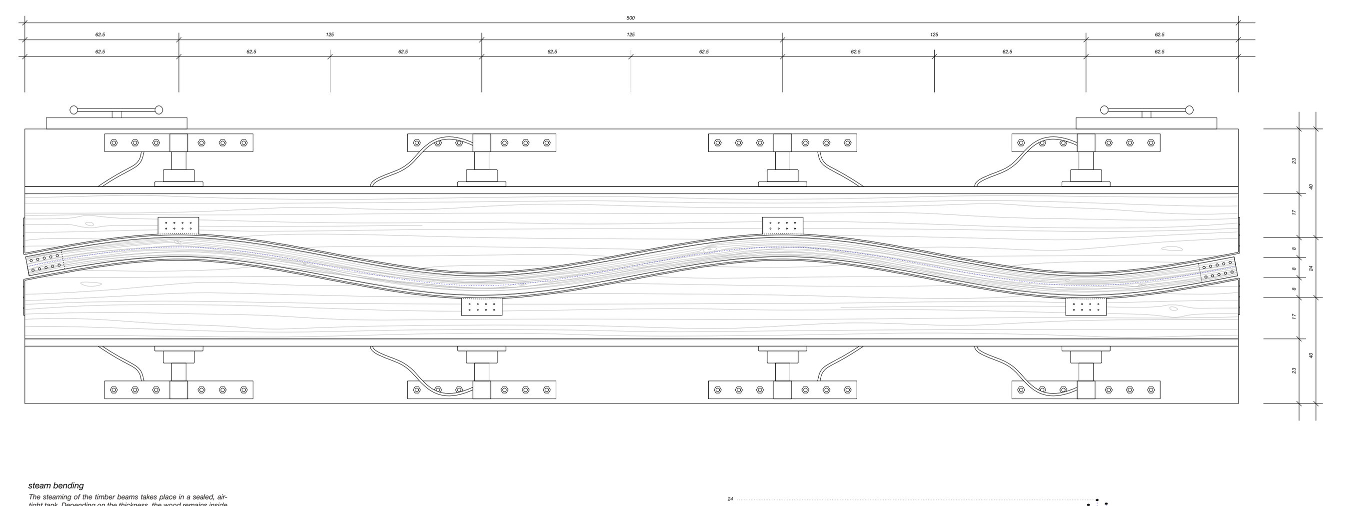
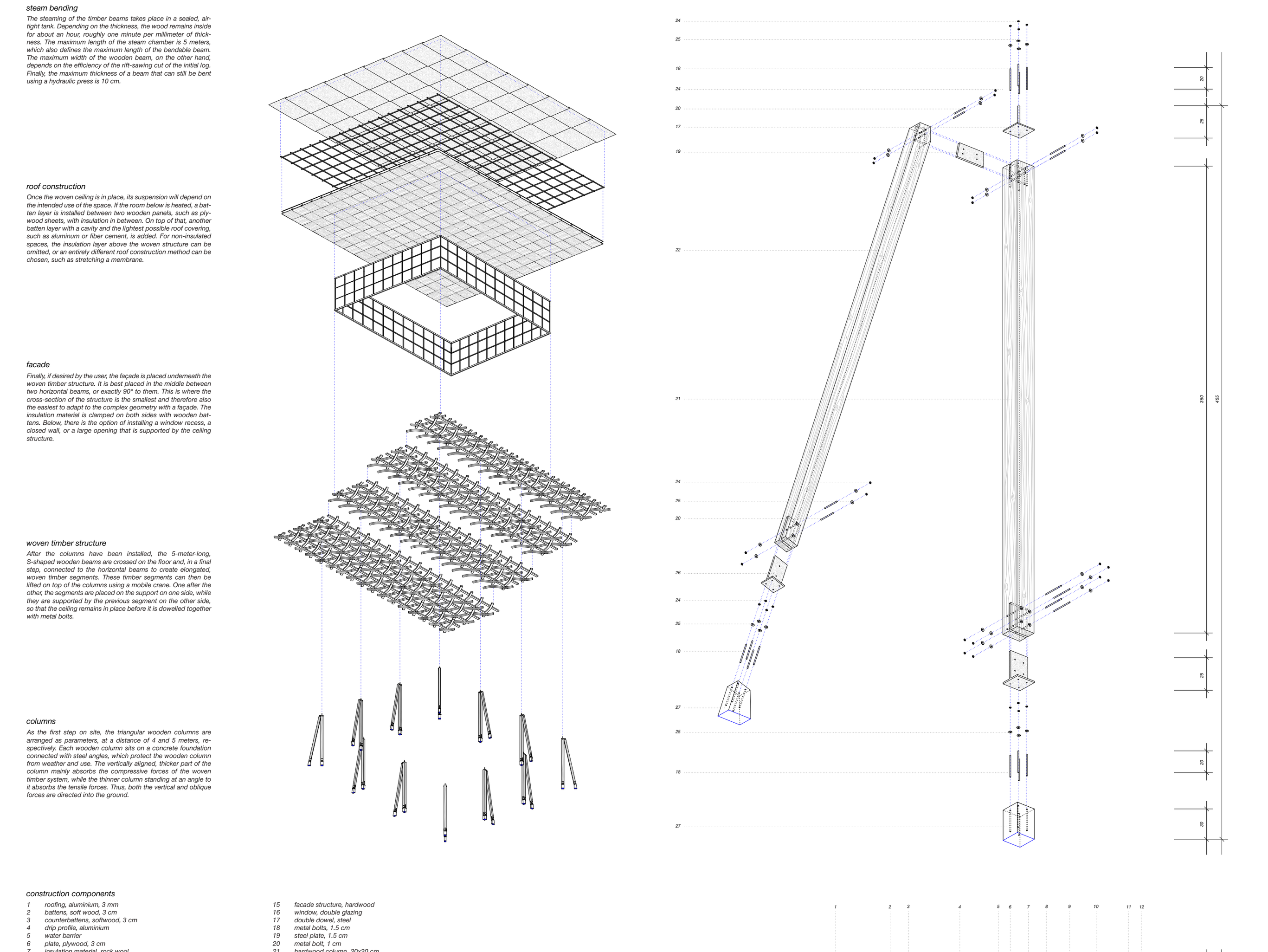
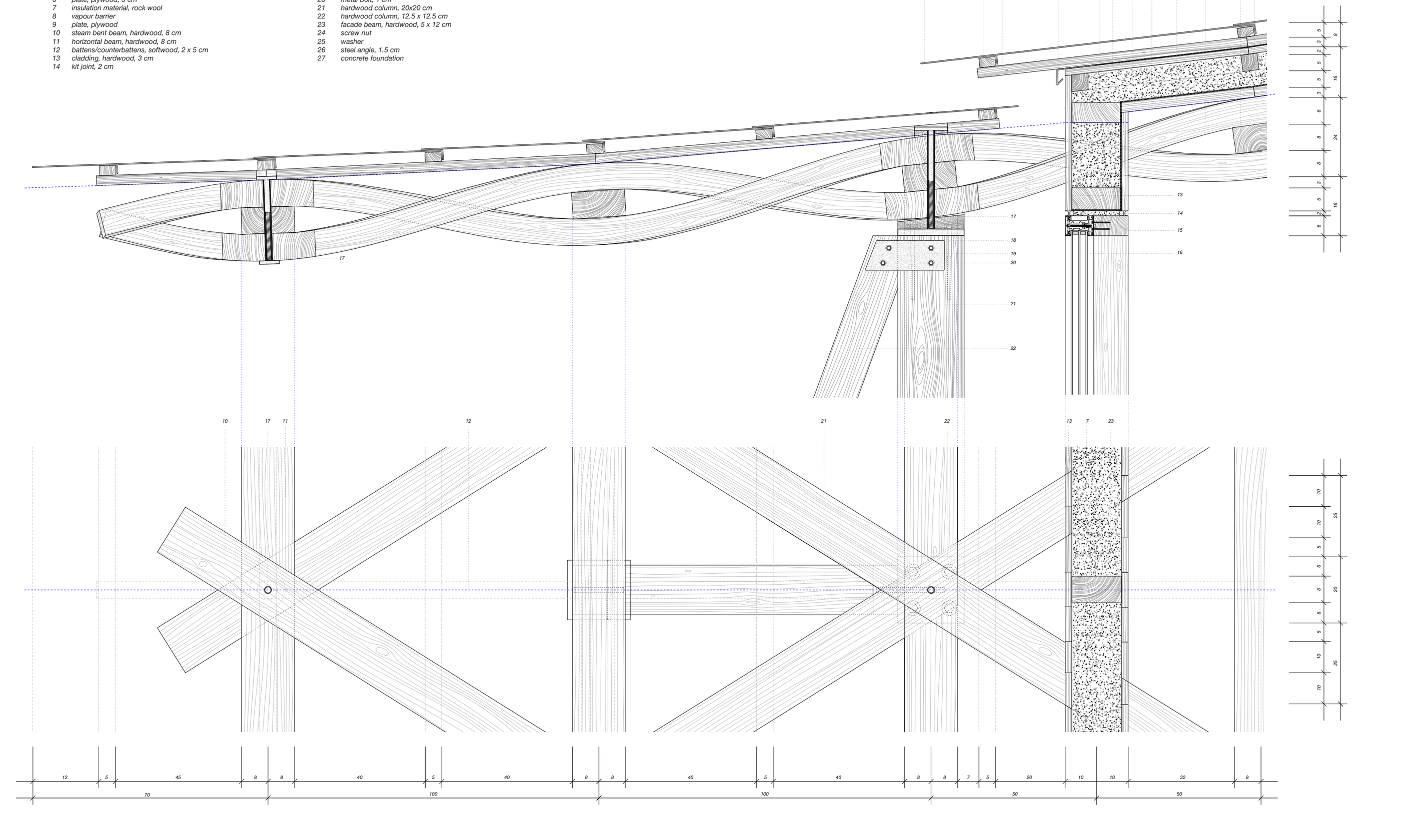
Establishing a connection between this research and the tradition of Swiss wood craftsmanship is especially significant. These traditional crafts produce hardwood vessels, specializing in intricate bending techniques and adhesive-free connection methods, and therefore holds knowledge worth preserving. With my uncle being one of the last three Weissküfer in Switzerland, my familial ties to this tradition inspire a reinterpretation of this craft into formal architectural expressions and construction methods. In addition to my uncle's workshop, I have visited four of Switzerland's ten remaining steam-bending practices. These visits provide me with valuable insights into existing machinery, the required timber properties, and the limitations of steam bending. Most importantly, I have learned that the largest steam-bent beams currently produced are about 5 meters in length and 10 cm in thickness.

Switzerland has a largely untapped hardwood potential. Although one-third of Swiss trees are hardwoods, 75% are immediately burned for energy purposes. Since steam bending requires hardwood, this presents an opportunity to utilize Switzerland's hardwood resources in a more sustainable manner. Furthermore, because steam bending does not damage the cellular structure of wood and does not involve glue or chemical alterations, it enables the reuse of wood multiple times after its initial use in a building, therefore extending the lifespan of each piece of timber. This reusability and recyclability is a major environmental advantage of steam-bent timber compared to more established timber construction methods like Cross-Laminated Timber.

Through experiments at scales ranging from 1:10 to 1:100, I gained knowledge about timber types and bending techniques, refining a formwork-based method for producing precise, high-frequency bent beams. These experiments lead to the development of several structural systems, including weaving, which has never been attempted at an architectural scale. Weaving timber both vertically and horizontally, progressing from straight to double-curved forms, proves to be not only visually compelling but also environmentally and structurally beneficial. The weaving method achieves structural height with less material, creating a dissolved, truss-like structure that is held together by geometry and gravity. The lightweight structure can span up to 15 by 12 meters, offering high material efficiency and dynamic spatial qualities, with ample daylight penetrating the space below.

The primary reason steam bending has not been applied at an architectural scale is the lack of facilities capable of producing such large-scale bent timber. To address these production limitations, this thesis proposes the establishment of a dedicated large-scale steam-bending facility. The facility will demonstrate the scalability of the woven timber structure and refine its construction logic and details, ensuring the practical implementation of steam-bent timber in architecture.

In the design of the production facility, the 15 by 12 meter module is arranged and repeated ten times, resulting in a 150-meter-long building that accommodates all the facilities needed for the large-scale steam bending of timber. Since the module is structurally supported on all sides, columns penetrate the space every 15 meters. However, this is not ideal for large-scale production, which requires an expansive, column-free space for practical reasons. To address this, a second woven timber layer is placed above the lower one, picking up the forces with a truss system and eliminating the need for columns that disrupt the space. Additionally, half a module (15 by 7.5 meters) is extruded from the upper level on its southern side, creating semi-enclosed, covered outdoor spaces for multi-purpose use, such as parking or storage. The lower layer of woven timber reaches a human scale, yet high enough to ensure practical production underneath. The higher level of woven timber allows trucks to pass underneath, even at its lowest point, while maintaining sufficient height at the highest point to maximize forklift use in the timber storage area. The dynamic space between the two layers can be used as a break room for workers or as an exhibition space for the products. Both timber layers are inclined to collect water, which is then drained towards the communal garden area, while also protecting the workspaces from direct sunlight and providing a large open facade towards the lake.

The combination of the users' behaviorology and the implemented structure is also a key aspect of this research. The A-shaped double columns create pockets that can be used by workers for gathering or storage. Additionally, ergonomic steam-bent furniture is integrated into the space, along with a steam-bent functional core. This steam bent core in between the restaurant and the production space hosts functions such as a service counter for the kitchen or seating benches as part of its perimeter.

In conclusion, this research explores the formal possibilities of steam-bent timber in architecture, focusing on its environmental and structural advantages. By developing the new structural system for weaving timber, this thesis aims to demonstrate the potential of this technique as an adhesive-free and material-efficient construction method. The proposed production facility not only examines the practical applications of a woven timber structure, but also seeks to utilize Switzerland's hardwood resources whilst preserving the profound tradition of steam bending.