**Introduction**

The construction industry has an extensive impact on the global environment (Eq. 1) and will be facing three big challenges in the next decades: reducing carbon dioxide emissions, reconsidering the make-use-dispose use, and limiting its waste production. This is even more crucial, considering global population growth and increasing urbanization. Consequently, a shift of paradigm from a linear economy of make-use-dispose towards a circular economy that advocates closed loops within the system of materials and components is required (Eq. 2). Recycling currently offers the common strategy to reuse mass-produced elements, such as metal or wood, and to reprocess (e.g., melting steel scrap). Indeed, direct reuse of components can often be ascribed to their original function, the potential to reduce environmental impacts further because sourcing additional raw materials is avoided and only few energy is spent for transformation [1]. In the case of structures and infrastructures, however, the recycling of structures is often less straightforward as the joining of stock elements has to be addressed. Another outstanding structure is the London Bridge Brussels, (Fig. 8) from a nearby development project. This means that the joining of stock elements has to be addressed. An additional challenge is the efficient use of the available element lengths. This is because of the big reuse and energy intensive joinery. These observations suggest that reusing structural elements has to go beyond the existing environmental footprint of building structures. Reused components may consequently have a longer service life than the systems to which they initially belonged and dissipate less carbon dioxide because fewer new materials are needed.

**Results**

The optimization method is applied to form-find truss systems subject to different component stocks. In each case, varying cross section sizes or element length result in a different outcome of the design. The results for the truss made from Stock A, (Fig. 4) are loaded at the top chord and are used as the initial topology for the introduced optimization method. The obtained layout for the case of using Stock A is reported in Fig. 5 (b). This stock consist of elements with 3.00 m in length which are n = 4 times available for each of the six cross-section groups. Due to limitations of the stock to 3.00 m elements, only the truss layout contains two arrays of these almost uniform lengths, which is composed of equivalent cross section groups but with variable element lengths, the found geometry is shallower and vaulted. Another result is a case study design of a structural scheme for the main truss section roof in Lausanne’s Olympic stables, shown in Fig. 6 (d) and (b). Further, the optimization method is applied to form-find truss systems subject to differently composed stocks. In each case, varying cross section sizes or element length result in a different outcome of the design. The results for the truss made from Stock A, (Fig. 4) are loaded at the top chord and are used as the initial topology for the introduced optimization method. The obtained layout for the case of using Stock A is reported in Fig. 5 (b). This stock consist of elements with 3.00 m in length which are n = 4 times available for each of the six cross-section groups. Due to limitations of the stock to 3.00 m elements, only the truss layout contains two arrays of these almost uniform lengths, which is composed of equivalent cross section groups but with variable element lengths, the found geometry is shallower and vaulted.

**Conclusion**

The proposed optimization and form finding method renders a first step towards facilitating the design with reused elements where the outcome is not predictable as in the well-established conventional structural design process. Future research will extend this method towards different structural typologies such as bending and frame systems. Further, the analysis of environmental impacts of different design methods and the comparison of the joining of stock elements has to be addressed. Another result is a case study design of a structural scheme for the main truss section roof in Lausanne’s Olympic stables, shown in Fig. 6 (d) and (b). Further, the optimization method is applied to form-find truss systems subject to differently composed stocks. In each case, varying cross section sizes or element length result in a different outcome of the design. The results for the truss made from Stock A, (Fig. 4) are loaded at the top chord and are used as the initial topology for the introduced optimization method. The obtained layout for the case of using Stock A is reported in Fig. 5 (b). This stock consist of elements with 3.00 m in length which are n = 4 times available for each of the six cross-section groups. Due to limitations of the stock to 3.00 m elements, only the truss layout contains two arrays of these almost uniform lengths, which is composed of equivalent cross section groups but with variable element lengths, the found geometry is shallower and vaulted. Another result is a case study design of a structural scheme for the main truss section roof in Lausanne’s Olympic stables, shown in Fig. 6 (d) and (b). Further, the optimization method is applied to form-find truss systems subject to differently composed stocks. In each case, varying cross section sizes or element length result in a different outcome of the design. The results for the truss made from Stock A, (Fig. 4) are loaded at the top chord and are used as the initial topology for the introduced optimization method. The obtained layout for the case of using Stock A is reported in Fig. 5 (b). This stock consist of elements with 3.00 m in length which are n = 4 times available for each of the six cross-section groups. Due to limitations of the stock to 3.00 m elements, only the truss layout contains two arrays of these almost uniform lengths, which is composed of equivalent cross section groups but with variable element lengths, the found geometry is shallower and vaulted.

**References**


**Fig. 1:** Responsibility of the building sector

**Fig. 2:** Linear and Circular Economy

**Fig. 3:** Conventional and Reverse Design Process

**Fig. 6:** Roof case study (a) reuse of transmission tower parts, (b) stock characterization, (c) design scheme, and (d) optimization results (left: initial topology and loads, middle: optimized layout, right: normal force pattern)

**Fig. 7:** Embodied energy comparison [2]

**Fig. 8:** SXL Ski Grid Shell: (a) bent grid shell pavilion, (b) existing airframe testing, (c) kill-or-parts, and (d) flat grid