New reinforcing element for automated production of reinforced concrete

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Summary
A new reinforcing element has been developed to provide production of reinforced concrete elements entirely digitalized and automated. This is not only an important contribution to the production of reinforced concrete elements in general, but also a contribution to Conceptual Design.

This is the first fully automated production of reinforced concrete elements in three phases: (1) production of reinforcement (2) mixing of the reinforcement to the fresh concrete and (3) placing of concrete into the formwork. The new reinforcing element has a special, 3-dimensional form. It is produced from a single wire in successive steps of bending and creating finally four closed loops that are connected in the same centre. The new reinforcing element is easy to mix to concrete and distribute randomly and uniformly without any difficulties even for relatively high amount. Present paper gives details of the new reinforcement and the new reinforcing technology.

1 INTRODUCTION

Decisions of technological aspects and suitable material use belong to the first priorities of any construction in the Conceptual Design phase. Other design aspects like structural system, harmony to the environment, durability and sustainability are also helping the to support the decision for technology and materials.

The digitalization and automation contribute:

- to Conceptual Design by flexibility in design and in execution, on the other hand, it contributes:
- to the production by saving labour and reducing construction time, i.e. increase speed of construction.

1.1 Speed of construction

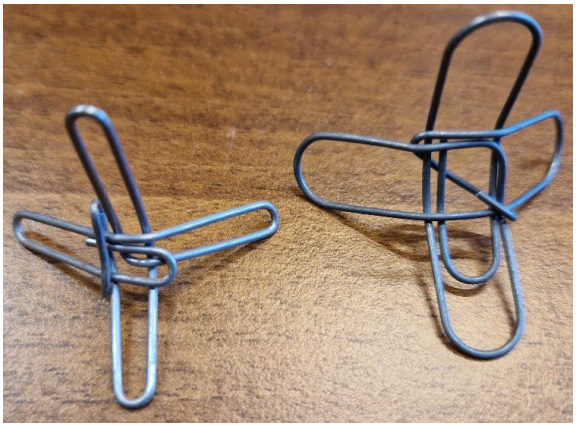
The speed of construction is important for the efficiency. For reinforced concrete structures in civil engineering the most difficult factor is the preparation of reinforcement system. It is very time consuming and requires a lot of labour.

To improve the speed of construction the way of the preparation of reinforcement must be improved.

1.2 Cost of construction

The cost of construction is highly influenced by the level of applied technology. Digitization and automation may help considerably to reduce the costs, especially in case of repeated applications. On the other hand, digitization and automation need specific machines and their repair.

To reduce the overall cost of construction the newest technology is necessary especially for production of large number of elements.



a) New reinforcing elements with different sizes, called: STAREX

b) Partial filling of a cube mould of 100 mm side lengths with the new reinforcing elements

c) Complete filling of a formwork (70×70×250 mm) with the new reinforcing elements

Fig. 1 The new reinforcing elements

2 NEED FOR AUTOMATION

Fields of digitization and automation are extending in almost every industrial sector. In case of construction industry, we must differentiate for design and construction as well as material production because these areas develop in different ways:

Design: there are several methods to help design in its different phases: speaking about preliminary design and detailed design phases.

Construction: may need more time to develop a completely new construction method including all elements for the formwork and the technology.

Material production: is largely supported by the needs of producing improved material properties that can fulfil higher expectations and to meet to more specific code specifications. The development of material production is much quicker compared to development of construction. However, there can have large differences for different materials.

Development for all these three phases: design, construction and material production largely depend on the:

- technical development as well as
- the development of new ideas or inventions.

Digitization and automation are important in different aspects and influences:

- to save labour
- to save time
- to improve productivity
- to improve quality
- to save space, i.e. requires smaller place for production.

One of the delaying components at every construction is the preparation and workmanship of reinforcement concrete elements before casting of concrete.

Some decades ago, *industrialization of reinforcement* for the concrete industry was an important step, which included wider use of wire mesh fabric, welded and bent cages for stirrup reinforcement etc [1]. The presented development is a challenge of generalization of reinforcing [2] [3].

3 NEW REINFORCEMENT

A new reinforcing element has been developed (Fig. 1). The new reinforcing element has a special, 3-dimensional form. It is produced from a single wire in successive steps of bending and creating finally four closed loops that are connected in the same centre (Patent: HU2017/050041, Csongor Czintos).

The new reinforcing element can have different diameters and different lengths of loops meeting the needs of various applications.

Fig. 1.a and Fig. 2a indicates the new reinforcing element, STAREX inslightly different lengths of loops and the opening of loops.

The STAREX elements can be mixed into the fresh concrete any amount, they are able to work efficiently together in the mix which is then called PERFYCON.

Fig. 1.b indicates the use of STAREX elements in a part of the cross-section which is possible. This photo is a visualization of reinforcement distribution using a transparent (glass) face of a cube of 100 mm sides.

Fig. 1.c indicates complete filling of a formwork (70×70×250 mm) with the new reinforcing elements. This type of STAREX application – complete filling of the formwork before infiltrating with mortar – is only necessary for special applications.

The new reinforcing elements are easy to mix to the concrete and distribute randomly and homogeneously without any difficulties even for relatively high dosages (Fig. 2.b). Mixing of reinforcing elements – preparing fresh concrete – is possibly in conventional mixers. The reinforcing elements can be added into the mixer and then mixed to distribute them. The reinforcing element are stiff enough for the mixing procedure.

Test results indicate excellent workability of fresh concrete and easy handling. Balling is completely avoided. By applying the new reinforcing elements, it is possible to incorporate them into the reinforcing procedure within the mixing and casting phases.

a) 1. STEP: Production of reinforcing element in three-dimensional form, STAREX is produced

b) 2. STEP: Mixing of concrete with the new reinforcing elements resulting PERFYCON

c) 3. STEP: Placing of PERFYCON reinforced concrete into the formwork

Fig. 2 Steps of full automation for production of reinforced concrete

4 FULL AUTOMATED PRODUCTION OF REINFORCED CONCRETE

The new reinforcing element provides production to be digitalized and automated:

1. **production of the new reinforcement element in three-dimensional form by machines** (Fig. 2.a)
2. **mixing of concrete with the new reinforcement elements** (Fig. 2.b) – distribution of STAREX elements is possible even in large amounts without balling

3. **placing of reinforced concrete into the formwork** (Fig. 2.c).

By using the new reinforcing element, full automation and digitalization of production reinforced concrete elements is possible from

constituents → through mixing with the reinforcing elements → to the final elements.

This is the first time when all the three phases of production of reinforced concrete can be automated.

5 WORKING SYSTEM

The three-dimensional reinforcing elements are distributed randomly in the fresh concrete after mixing considering both the centroids of the reinffocing elements as well as the direction of the loops. These indicate *homogeneity* and *isotropy* for the mix.

STAREX elements are efficient if there is enough overlapping of the loops (Fig. 3). Without overlapping there is no interaction, nevertheless, there is a minimum number of reinforcing elements that is required.

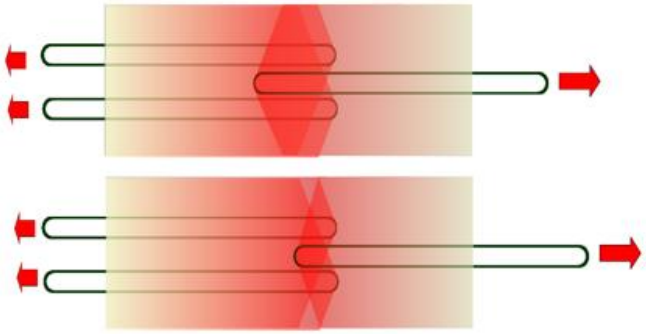


Fig. 3 Visualization of necessary overlapping

The force transfer is produced from every loop to the neighbiouring one by compression in the concrete between them. The geometry of the loops depends on the application (Fig. 4).

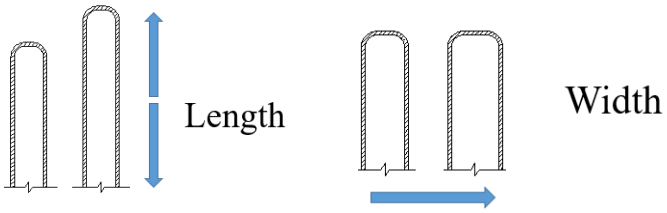


Fig. 4 Length and width of loops depend on the application

6 APPLICATION

The following applications is a beam of 2 m length; span: 1.8 m; cross section: 100x150 mm. Un-notched. Average concrete compressive strength with the fibres: 152 N/mm^2. STAREX content: 240 kg/m^3 Starex steel elements for flexure and for shear together (Fig. 5). It indicated large deflection until failure.

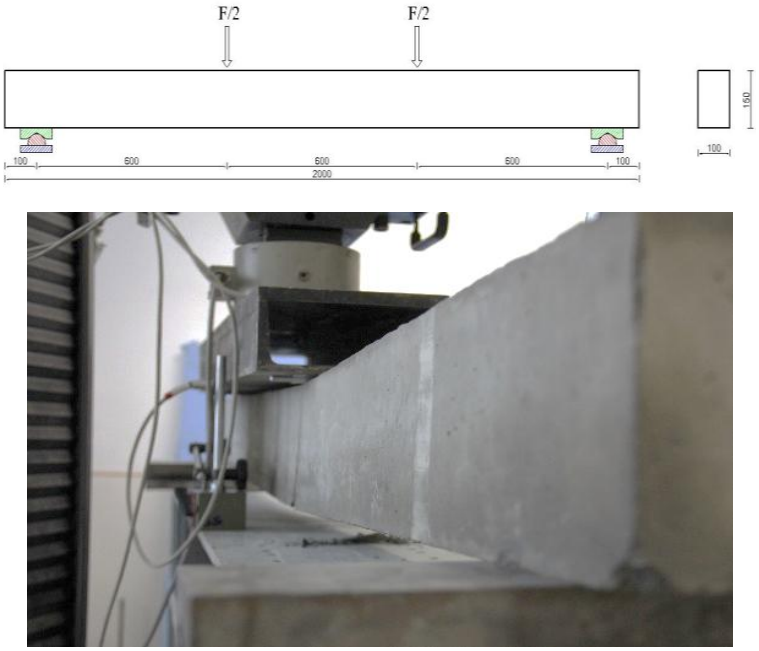


Fig. 5 2 m long PERFYCON beam in testing

7 CONCLUSIONS

Conceptual Design is largely related to developments in structural systems as well as developments in construction methods. Nowadays, the speed of construction is of outmost importance both in technical and economical respects (Fig. 6).

Fig. 6 Fully digitized and automated production of reinforced concrete elements

One of the delaying components at every construction is the preparation and workmanship of reinforcement concrete elements before casting of concrete. The speed of construction is often related to the level of automation of construction phases which is the main topic in this contribution.

A new reinforcing element has been developed. The new reinforcing element enables to incorporate the reinforcing procedure within the mixing and casting phases. The new reinforcing element has a special, 3-dimensional form. It is produced from a single wire in successive steps of bending and creating finally four closed loops that are connected in the same centre. The new reinforcing element is easy to mix to concrete and distribute randomly and homogeneously without any difficulties even for relatively high amount.

The new reinforcing element has been developed to provide production of reinforced concrete elements entirely digitalized and automated. This is the first fully automatic production of reinforced concrete elements with the three phases of production can be automated (Fig. 2):

1) production of reinforcement in three dimentsional form
2) mixing of the reinforcement to the fresh concrete
3) placing of reinforced concrete into the formwork.

The herein presented method gives a major contribution to Conceptiual Design through the automated production of reinforced concrete elements.

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