Using nondestructive methods for determination types of rebar splices

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Abstract. The article considers the types of rebar splices in reinforced concrete building structures. Examples of couplers and lap splices of reinforcing bars with a diameter of 20 mm are given. The main task of the work is to analyze the results of tomographic studies of various concreted splices. The studies were performed using the MIRA A1040 low-frequency ultrasound tomograph. Conclusions about the possibility of using the ultrasonic method to determine the types of splices were made.

1. Introduction
The inspection of reinforced concrete structures requires determination of rebar placing and comparison with the project according to requirements (determination of rebar spacing, rebar diameter and a value of concrete cover), [1] in addition, in the construction of reinforced concrete structures, there are requirements for rebar splicing.

The currently known types of rebar connections can be divided into two types: overlapped splices (Fig. 1) and connection via various couplers (Fig. 2). The splicing of reinforcing bars can be accomplished by welding and wire tying. Coupling joints are more diverse and are implemented by several methods of connections (threaded coupling splicing, splicing made by compression of the rebars, splicing by welding, welded splicing using two overlays of reinforcing bars of the same diameter). This article presents the experience of determining different types of splices [2-4].

Figure 1. Overlapping rebar splice
2. Methodology

2.1. Object of research description

3 types of splices were selected for the study: overlap joint (Fig. 1), splice with two overlays (Fig. 2.4), as well as a solid reinforcing bar without connection. This choice was made in order to evaluate the possibility of determining different types of splices, overlap connection and other connections (from a solid rod “without connection” to the most pronounced in terms of geometry of the connection with two welded overlays).

Data for evaluating the connection with two overlays were obtained on a created reinforced concrete slab (Fig. 3), the data for determining the overlap connection was obtained when examining a reinforced concrete column at the lower part where overlapping slicing is made, at the splicing of the rebar outlets with the column rebar frame. Data for a solid rod without a joint were obtained when examining a reinforced concrete column at a distance from the rebar splicing.

Figure 2. Types of rebar splicing:
1 – Threaded Couplers; 2 – compression splicing; 3 – splicing by welding; 4 – welded splicing using two overlays of reinforcing bars of the same diameter
2.2. Description of the ultrasonic tomography.
In this research MIRA A1040 device was used (Fig. 4), whose work is based on the ultrasonic method [4-8].

The measuring equipment contains a matrix antenna array of 48 (12 blocks of 4 elements each) [9] low-frequency shear-wave converters with dry point contact [10].

The device uses the method of synthesized focused aperture with combination sensing (SAFT-K), in which the ultrasound is focused to each point of the half-space. The data array is formed by collecting information from all measurement pairs of the tomograph antenna device. The signals received by the antenna array are processed on the embedded computer directly during operation.

An ultrasonic pulse-Echo method is used in the device. The ultrasonic wave propagates through the material and reflect by an encountered discontinuities. The wave are reflected and received by another transducer. Thus, this method is able to determine the presence of inhomogeneities regardless of the material size, the results of tomography scanning depends on the frequency of the ultrasonic wave and the quality of the concrete.

After processing the measurements, the device displays the result as a color indication that displays the wave reflection pattern (amplitude) from blue to red. During postprocessing it is complicated to define the sizes of the inhomogeneities since it depends on the material, separating boundary surface, concrete quality and equipment settings. However, the device allows to accurately determine the relative sizes of inhomogeneities. For example, if dimensions of some heterogeneity are 2 times larger
than another. This principle is used in the interpretation and analysis of the results obtained in this research.

3. Results and discussion
As a result of an ultrasonic experiments, following data were obtained (fig. 5, 6, 7)

**Figure 5.** Results of determination of welded splice using two overlays of reinforcing bars

**Figure 6.** Results of determination of a rebar

**Figure 7.** Results of determination of the overlapped splice
Analysis of the results:
1. According to the results of ultrasonic tests (Fig. 5) it can be seen that there is an increasing in inhomogeneity width on both sides of the main rebar, approximately by the size of the middle rod. That is, there is a 3 times increasing in the rod width what corresponds to the splices with the welded by two overlays.
2. According to the ultrasonic tests the size of the overlays were determined as a 337 mm. what does correspond to the real size of the overlays that was a 326 mm. According to this comparison the results can be considered as a good one.
3. The signal reflection area in figure 6 looks smooth throughout the longitude without significant changes in width, which proves the presence of only one reinforcing bar. However, it can be assumed that this zone may be spliced by small width couplers
4. Figure 7 shows an increasing in the reflection zone by approximately two times relatively to the main reinforcing bar. The inhomogeneity zone ends abruptly, which allows us to conclude that the rods splicing is made as an overlapping.
5. Relying on the obtained experience, it can be concluded that the splicing with a threaded coupling, splicing made by compression and other coupler types will have a width increasing zone about 10-15%

4. Conclusions
The materials of the conducted research shows that the issue of determining the rebar splicing types and its parameters can be performed using tomographic research.

In the future, for a more complete study of the issue of the reinforcing bars splicing, it is necessary to examine connections of different diameters with a different concrete cover and with different lengths of connecting elements. A set of research experiences will help to evaluate the splicing type and its parameters more reliably in the future.

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