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# Mechanical properties of cement pastes with fine old concrete, influence of different type of approach mixing

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**Abstract.** The article focuses on the impact of different type of approach mixing on resulting mechanical properties of cement composites. We investigate of influence speed of mixing of fresh mixtures and process of mixing the individual components of the cement composite. The mechanical properties were investigated by using non-destructive resonance method and destructive method on samples with dimensions equal to 40 × 40 × 160 mm. Among the monitored mechanical parameters were dynamic modulus of elasticity, dynamic shear modulus, flexural strength and compressive strength.

## Introduction

The amount of waste old concrete is growing year after year and the need for its efficient use with it [1, 2]. Nowadays recycled concrete is used as coarse and fine aggregate in new concrete [3, 4]. The properties of the resulting composite are not only directly dependent on the grain shape which is in the case of recycled concrete is not suitable but also on the size of the transition zone. These effects have a negative effect on the resulting properties [5]. Recently, there have been studies in which the ITZ can be partially eliminated using the correct mixing approach, i.e., the correct procedure of mixing of the components of the cement composite and the mixing speed [6].

Unlike mentioned researches which they focus on recycled coarse aggregate, we focused on mechanical activated old concrete. This is fine aggregate with modified grain shape by using high-speed milling process [7]. The micronizing of the old cement paste into fine particle results in uncovered unhydrated clinker minerals, which can further hydrate upon contact with water [8].

## Materials and Samples

Cement pastes composed of 50 wt. % Portland cement CEM I 42.5R from Radotin and 50 wt. % fine recycled old concrete has been prepared for investigating the impact of different mixing approach. Fine recycled old concrete was obtained from an old construction concrete (sleepers and columns) and micronized by high-speed milling process. Water ratio was equal to 0.35. The difference between individual samples was in the approach of mixing fresh mixtures. Two different components were mixed at 132 rpm for 240 seconds in the first step of the mixture preparation. In the second step, the remaining third component was added and the mixtures were mixed for 240 seconds at two different speeds, namely 132 rpm and 421 rpm. Approach of mixing is shown in Table 1.

Table 1: Approach of mixing fresh mixtures

| | The first step of mixing | | The second step of mixing | |
|---|---|---|---|---|
| Set | Components | Speed [rpm] | Added component | Speed [rpm] |
| RW+C_S | Recycled old concrete and Water | 132 | Cement | 132 |
| RW+C_F | Recycled old concrete and Water | 132 | Cement | 421 |
| CR+W_S | Cement and Recycled old concrete | 132 | Water | 132 |
| CR+W_F | Cement and Recycled old concrete | 132 | Water | 421 |
| CW+R_S | Cement and Water | 132 | Recycled old concrete | 132 |
| CW+R_F | Cement and Water | 132 | Recycled old concrete | 421 |

**Experimental Methods**

Investigated mechanical parameters were developments of dynamic modulus of elasticity and dynamic shear modulus and values of flexural strength and compressive strength. The development of the dynamic modulus of elasticity and dynamic shear modulus was measured non-destructively in the first 28 days after the start of cement hydration. The Flexural and compressive strength values were measured destructively on 28 day old samples.

Measurement of the dynamic modulus of elasticity was carried out be using resonance method, namely the measurement line from Brüel & Kjær. The measurement line was consisting of a measuring unit type 3560-B-X12 impact hammer type 8206, an acceleration sensor type 4519-003 53422 and software PULSE LabShop. The dynamic modulus of elasticity was achieved by using the basic longitudinal natural frequency and basic flexural natural frequency of the samples. The dynamic shear modulus was achieved by using the basic torsional natural frequency of the samples.

The flexural and compressive strength were determined be using destructive method on the device FHF Strassentest. The flexural strength was determined by a three-point bending test. The testing of flexural strength was displacement controlled at a constant rate of 1 mm/min. The distance between supports for three-point bending test was equal to 100 mm. The compressive strength was determined by using uniaxial compressive test. The uniaxial compressive test was performed on the broken halves of the samples after bending test with effective dimensions of 40 × 40 × 80 mm. The testing of compressive strength was displacement controlled at a constant rate of 5 mm/min.

**Results and Discussion**

Results of non-destructive testing are shown on Fig. 1. The results show the positive effect of the mixing speed of the fresh mixture on the dynamic modulus of elasticity and the dynamic shear modulus. Differences between the highest and lowest value modules were between samples CR+W_S and samples CR+W_F, namely 0.5 GPa for dynamic modulus of elasticity and 0.3 GPa for dynamic shear module. The highest increase of dynamic modulus of elasticity and dynamic shear modulus is in the first 10 days of sample age. Furthermore, the increase in values is gradual in the next 18 days.

Flexural strength was approximately same value on all testing samples (Fig. 2). Differences were up to size of the value standard deviation. Value of flexural strength was 4.5 MPa. In contrast of it, the compressive strength values (Fig. 2) were different and they have same trend of value of dynamic modulus of elasticity. The greatest value of compressive strength had RW C_F, namely 40.8 ± 2.8 MPa and lowest value of compressive strength had

CW+R_F, namely 28.1 ± 1.1 MPa. Value of standard deviation was approximately 5 % of value compressive strength in all tested case.

The results show that the mixing speed has a positive effect on the resulting compressive strength, with a difference of approximately 5 MPa for slow and fast mixing of RW + C and 4 MPa for slow and fast mixing of CR + W. This is the effect of better homogenization of the fresh mixture by fast mixing. The mixture RW+C (the old concrete was first mixed with water and then with the cement) had the highest compressive strength values, namely 5 MPa higher than the mix where the first old concrete was mixed with the cement. The mixture where the cement was first mixed with water had the lowest compressive strength by about 5 MPa lower than in the case of cement first mixing with the old concrete and 10 MPa lower than the mixture where the recycle was first mixed with water. The process of mixing the individual components of the cement composite affects the ITZ zone between the cement matrix and the recycle grains.

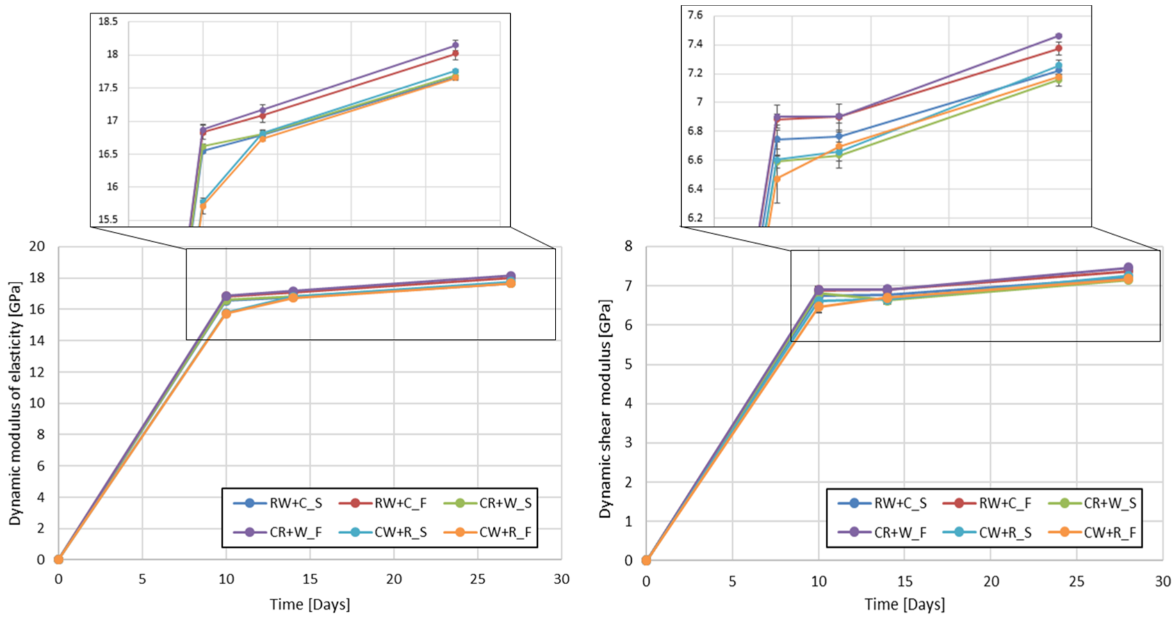


Fig. 1: Developing of dynamic modulus of elasticity – left and dynamic shear modulus – right (with standard deviations)

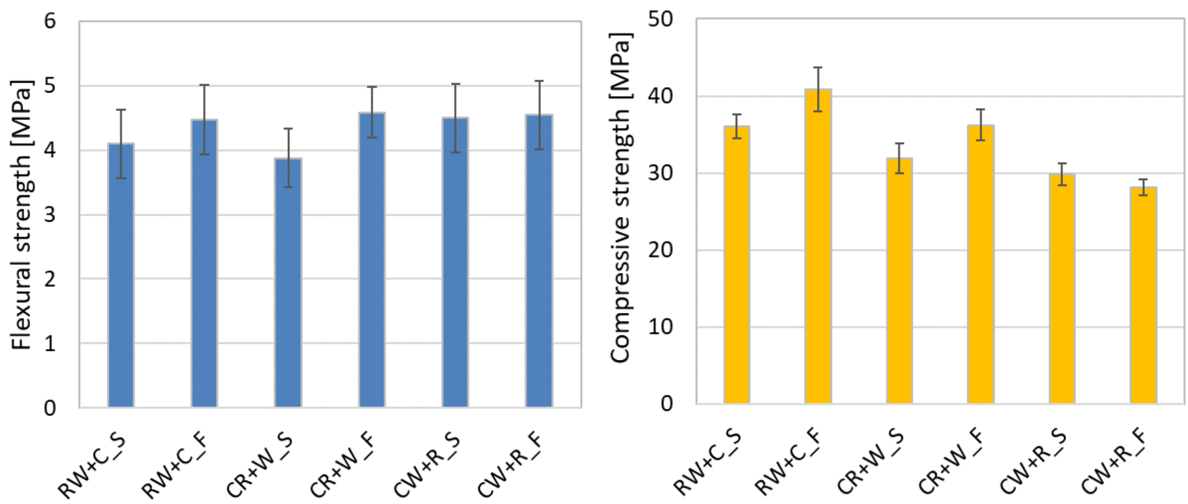


Fig. 2: Value of flexural strength – left and compressive strength – right (with standard deviations)

## Conclusions

This work was focused on the influence of different type of approach mixing on mechanical properties of cement composites. The researched samples were composed of Portland cement and micronized recycled old concrete. The difference between individual samples was in the approach of mixing fresh mixtures. Based on the results, it can be concluded that results of the work are in agreement with the statement of V.W.Y. Tam et al. [6]., because the size of ITZ zone depends on the approach of mixing not only in recycled coarse aggregate but also in micronized recycled old concrete.

In the future, the research will focus on confirming influence on approach of mixing on ITZ zone by using scanning electron microscope with X-ray microanalysis, namely an Energy Spectrometer.

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