# Experimental comparison of cracks width and cracks spacing results for beams of self-compacting concrete (SCC) and conventional concrete for period t = 400 days

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## ABSTRACT

Concrete is a material which has found a wide usage in engineering especially in construction engineering and road infrastructure facilities. Development trends for high rise constructions, modern skyscrapers indicate that building such constructions with normal concretes and low consistency is impossible, therefore there is a need for concrete with high processes because of great amount of reinforcement in cross-section of concrete elements. Solution for such construction is self-compacting concrete because of its ability to fill good formworks without compaction and vibration. Considering this fact, researches for cracks, mechanical characteristics of concrete and deformations have been conducted worldwide. In this line, we conducted an experimental research to determine the cracks on beams of self-compacting concrete and compared it with conventional concrete. The experimentally-obtained results will be presented for both types of concrete for: module of elasticity, compression strength, crack with and cracks spacing for duration failure testing time t = 400 days.

## Keywords

*Self-compacting concrete, conventional concrete, compression strength, cracks, modulus of elasticity*

## PREFACE

Self-compacting concrete like anywhere else in the world, as well as in Kosovo has been used widely in building construction, especially in high buildings and rehabilitation of existing facilities.

For the illustration purposes of this publication, we have conducted a thorough research for different beams in order to measure their distorting features (cracks, deformations, cuts, etc…) under both short-term as well as long-term loads.

To achieve this objective, we have prepared a number of test samples and the 18 beams used have been categorized in three series:

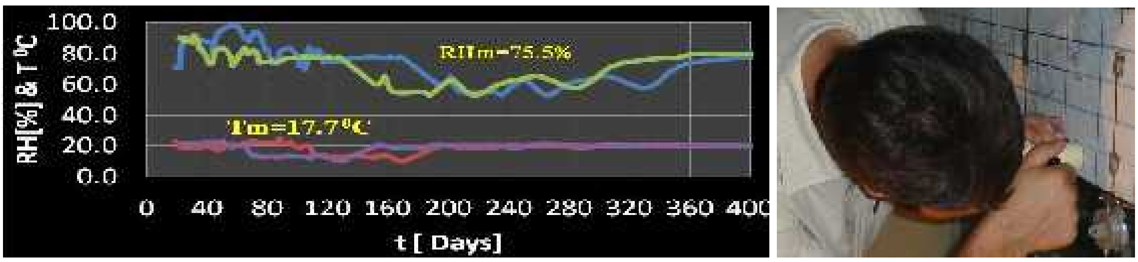
A Series – six beams of conventional concrete,
B Series – six beams of self-compacting concrete and
C Series – other six beams of conventional concrete core and coils of self-compacting concrete.

This publication aims to discuss the experimental findings for both types of conventional concrete and self-compacting concrete by comparing their performances for modules of elasticity, compression strength and the size of cracks for both types of beams during the duration testing time t = 400 days.

Figure 1 below shows temperature measuring and porosity as well as cubical, cylindrical and prismatic sample for the two types of concrete, whereas Diagram 1 presents the relative humidity and temperature during the research period in this long lasting process.

Fig. 1 Measuring the temperature and porosity on concrete

Diagram 1  Relative humidity and temperature




## 1. TESTING OF MODULUS OF ELASTICITY  ASTM C 469

Figure 2 below presents the testing of *modulus of elasticity* whereas Diagram 2 lists testing results for both conventional and self-compacting concrete.

*Fig.2. Testing of modulus of elasticity*

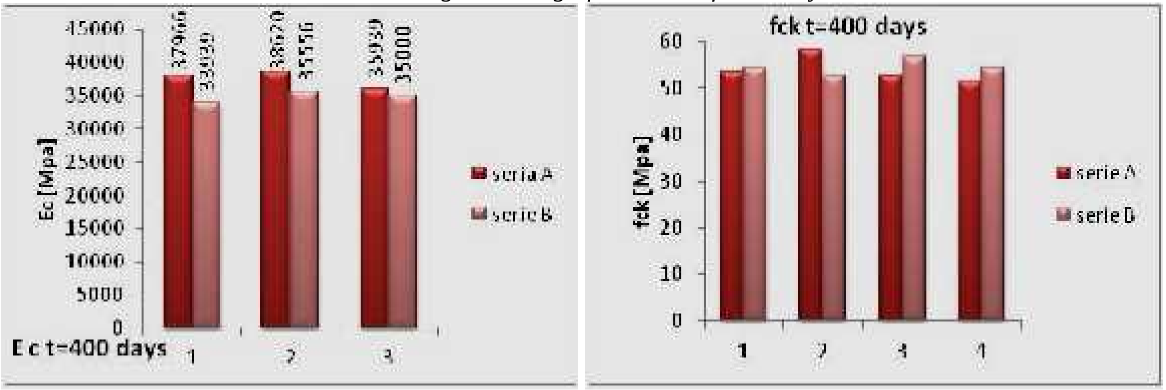



*Diagram 2. Testing results of modulus of elasticity and compression strength*

## 2. STATIC SCHEME OF DHE BEAMS

The static scheme is basically a simple beam loaded with two centered forces. The cross-section dimensions of beams used in this case study are 15x28 cm, their length 3m, reinforced with two fi-12 bars on the bottom (static bars) and other two fi-8 bars on the top (constructive bars) as show in Fig 3. In figure 4 is presented the failure test of the beams for testing period of t= 400days.

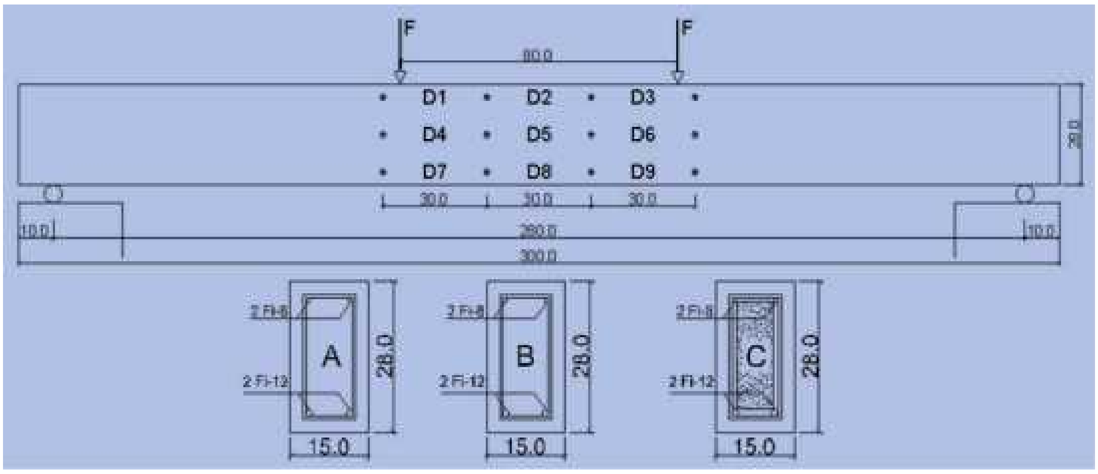



*Fig. 3. Static scheme and cross-section of the beams*

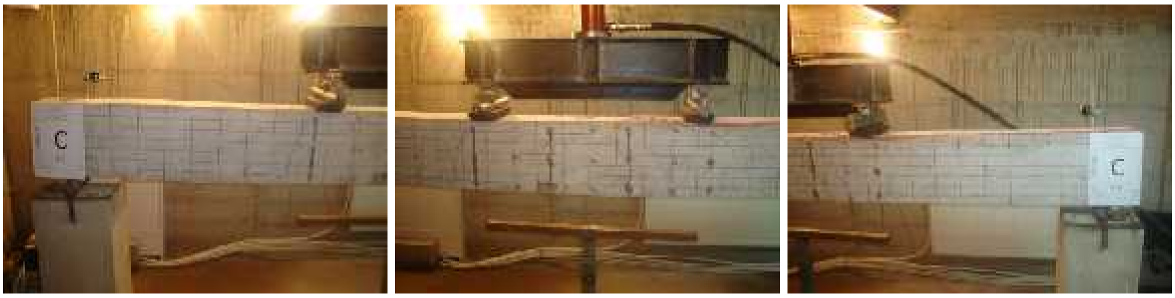



*Fig. 4. Testing of beam in failure on the time t = 400 days*

## 3. TEST RESULTS OF CRACKS DEVELOPED ON DEFLECTED BEAMS

Figure 5 below presents the results of diagrams listing the development of cracks for beams of series A, B and C for the duration testing time = 400 days.

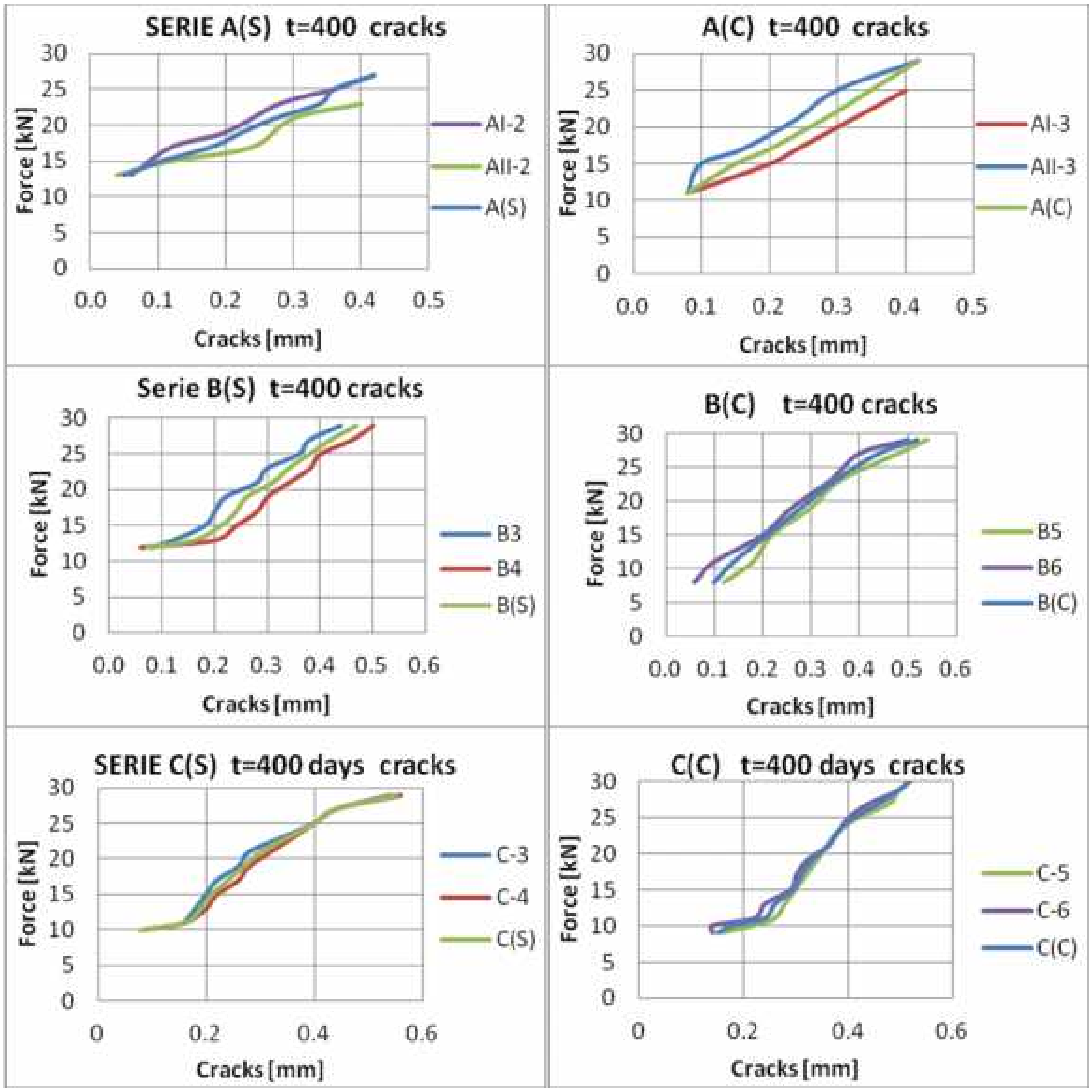



*Fig. 5. Increasing size for different level of load action on beams*

The development of cracks on beams has been measured for every force incremented during the testing period (the maximal burst) by using a special microscope. The development of fresh cracks along the entire length of the beams has also been evidenced and marked for every force values that have caused those crack spacings. The size of the crack spacings is shown in Figure 6.

In order to identify the developed cracked area on beams, the beams are split in areas of 10 cm horizontally by 4cm vertically. Cracks spacing and their distribution samples along the beams are presented in Figure 7.

The initial crack on beam AI-2 occurs when acting upon it with force of F=13kN thus causing the cracks width of w=0.06mm whereas the crack on beam AII-2 occurs after acting upon it with F=13kN in which case, the cracks width will be w=0.04mm

Similarly, the initial crack on beam B-3 occurs when acting upon it with F=12KN thus causing the cracks of width w =0.08mm, while on B-2 beam, the first crack to occur was that when acting upon it with F=12kN causing the crack width of w=0.06mm.

For beams C-3 and C-4, the following results were obtained: when acting upon C-3 with F=11kN the crack width developed was w=0.06mm whereas when acting upon C-4 with F=10kN, the crack width develped was w=0.08

On beams treated with expansion/deferment, the initial cracks were developed during the loading time and the same were developed on a timely basis.

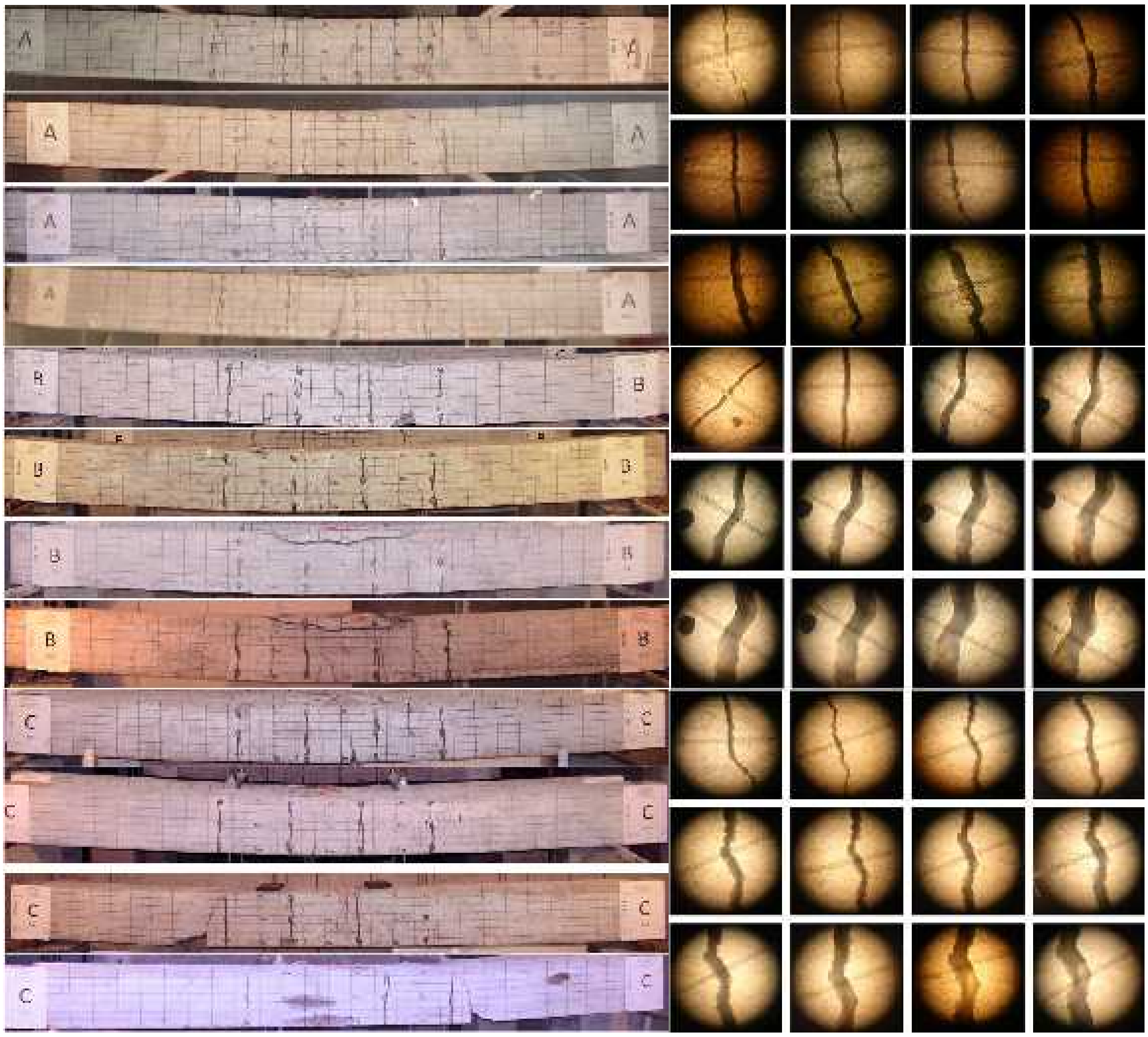
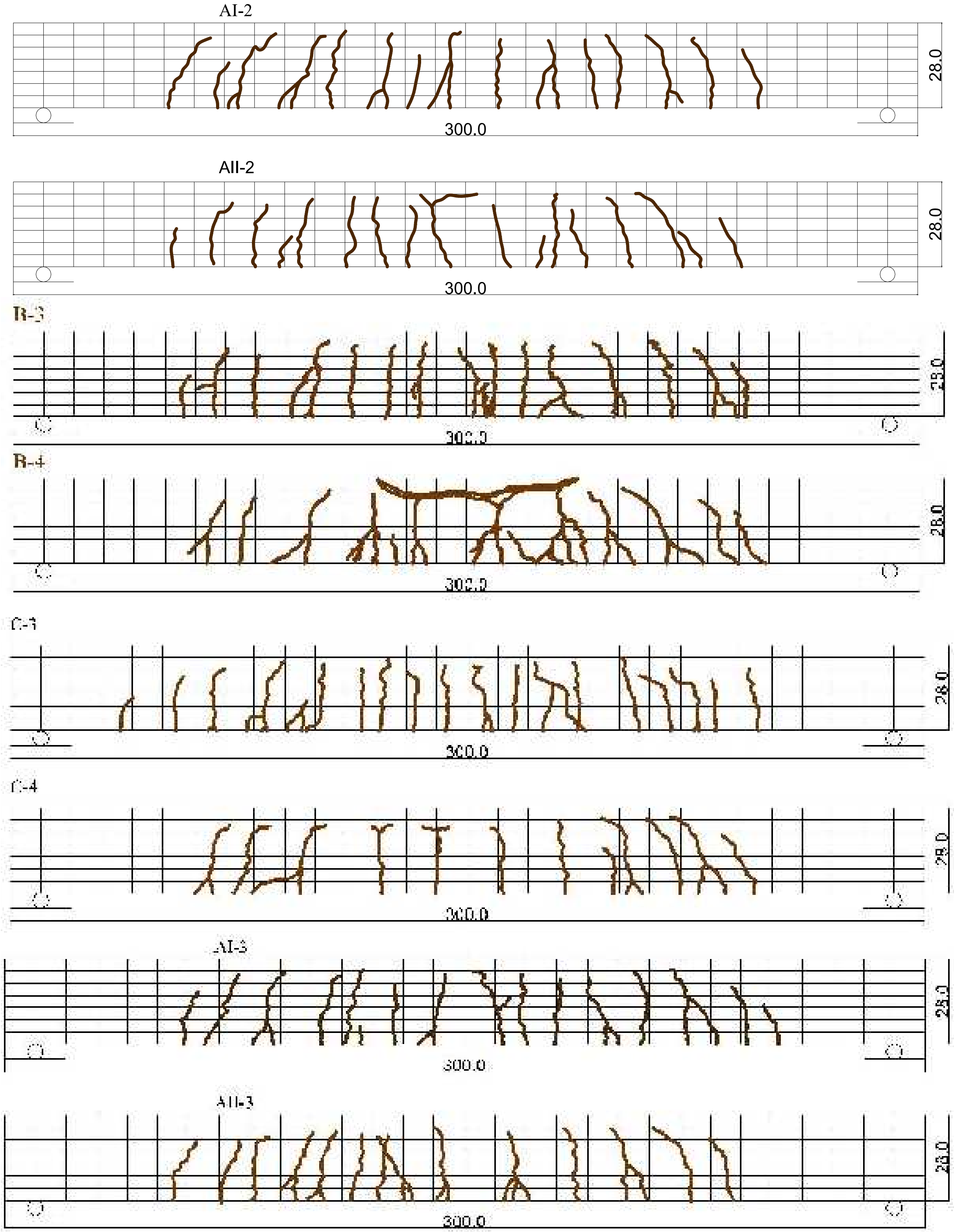


*Fig.6. Increasing the size of the cracks for different levels of force action on the beams*


AI-2
28.0
300.0
AII-2
28.0
300.0
B-3
28.0
300.0
B-4
28.0
300.0
C-3
28.0
300.0
C-4
28.0
300.0
AI-3
28.0
300.0
AII-3
28.0
300.0

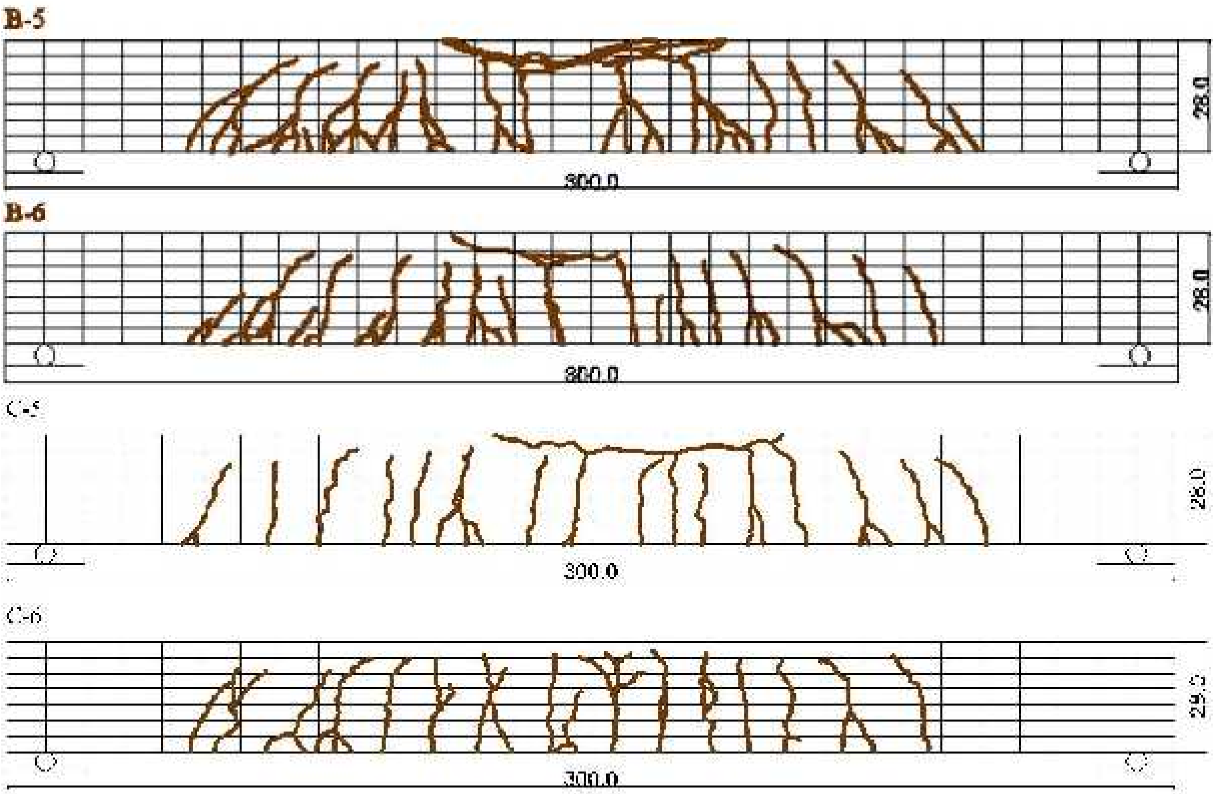



*Fig. 7. Development of cracks in the length of beams*

## 4. COMPARING CRACK SPACING RESULTS

Table 1 below provides a numerical presentation of results of cracks for beams of series A, B and C, for duration testing time of t=400 days (for unloaded beams – shrinking time) whereas Table 2 presents crack results for same duration testing time t=400 day (for loaded beams – creeping time)

Tab. 1. Comparison of results of cracks for beams of series A (S), B (S), C (S)

| | A(S) | B(S) | C(S) | A-B | A-C | B-C |
|---|---|---|---|---|---|---|
| *FORCE* | W (mm) | W (mm) | W (mm) | | | |
| **10** | 0.00 | 0.00 | 0.08 | | | |
| **11** | 0.05 | 0.00 | 0.16 | | 68.75 | |
| **13** | 0.07 | 0.07 | 0.19 | 0.00 | 63.16 | 63.16 |
| **15** | 0.10 | 0.16 | 0.21 | 60.00 | 52.38 | 23.81 |
| **17** | 0.18 | 0.21 | 0.24 | 16.67 | 25.00 | 12.50 |
| **19** | 0.18 | 0.24 | 0.27 | 33.33 | 33.33 | 11.11 |
| **21** | 0.23 | 0.26 | 0.30 | 13.04 | 23.33 | 13.33 |
| **23** | 0.28 | 0.34 | 0.35 | 23.64 | 21.43 | 2.86 |
| **25** | 0.34 | 0.38 | 0.40 | 11.76 | 15.00 | 5.00 |
| **27** | 0.36 | 0.42 | 0.44 | 16.67 | 18.18 | 4.55 |
| **29** | 0.42 | 0.47 | 0.55 | 11.90 | 23.64 | 14.55 |
| | | | **DIFFER ON %** | **20.78** | **30.61** | **16.76** |

Tab.2. Comparison of crack results for beams of series A (C), B (C), C (C) t = 400 days

| | A(C) | B(C) | C(C) | A-B | A-C | B-C |
|---|---|---|---|---|---|---|
| *FORCE* | W (mm) | W (mm) | W (mm) | | | |
| 9 | 0.08 | 0.10 | 0.15 | | 46.67 | 33.33 |
| 11 | 0.08 | 0.14 | 0.24 | 75.00 | 66.67 | 41.67 |
| 13 | 0.11 | 0.19 | 0.26 | 72.73 | 57.69 | 26.92 |
| 15 | 0.15 | 0.21 | 0.30 | 40.00 | 49.15 | 28.81 |
| 17 | 0.20 | 0.25 | 0.31 | 25.00 | 35.48 | 19.35 |
| 19 | 0.24 | 0.28 | 0.33 | 16.67 | 27.27 | 15.15 |
| 23 | 0.30 | 0.35 | 0.38 | 16.67 | 21.05 | 7.89 |
| 25 | 0.35 | 0.39 | 0.41 | 11.43 | 14.63 | 4.88 |
| 27 | 0.38 | 0.44 | 0.46 | 15.79 | 17.39 | 4.35 |
| 29 | 0.42 | 0.52 | 0.50 | 23.81 | 16.00 | 4.00 |
| | | | DIFFER ON % | **33.01** | **33.93** | **16.11** |

Figure 8 below on the other hand, presents the diagrams of comparison of test results for beams of series A, B, C (beams which are examined in shrinking for t=400days *A(S), B(S), C(S)* - unloaded beams and beams which are examined in crawling for t=400days *A(C), B(C), C(C)* - loaded beams).

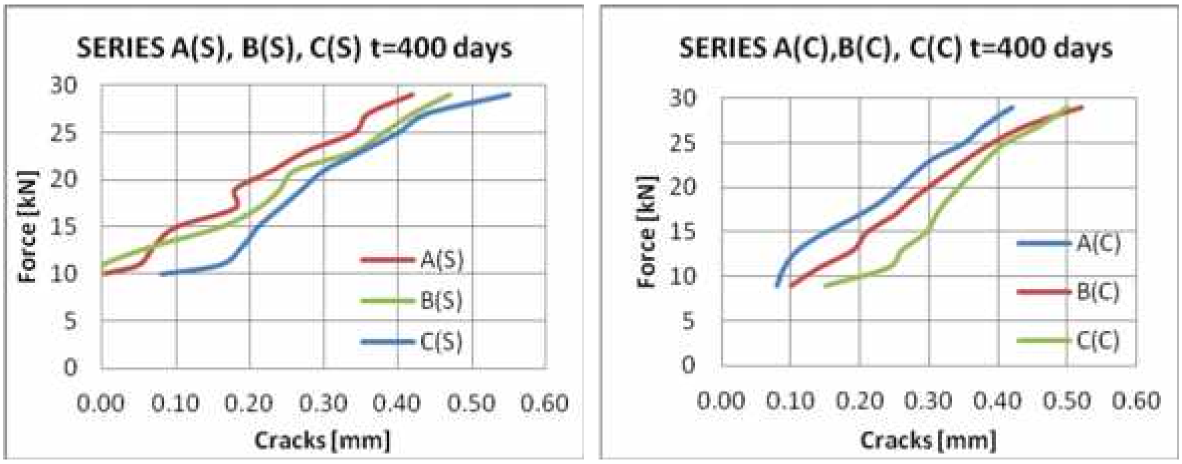



Fig. 8. Comparison of cracks diagrams-series A(C), B(C), C(C) (Loaded beams- crawling) and series A(S), B(S), C(S) (unloaded beams-shrinkage).

After comparing diagrams from figure 8 above, it can be noted that, for same testing period duration, beams of series C suffered widest cracks, while beams of series A were affected the least.

## CONCLUSIONS

Based on the results obtained during the experiment, the following conclusions can be drawn:

- Self-compacting concrete has smaller modulus of elasticity than conventional concrete.
- Small difference in results was encountered between beams of series B and C averaged 16% while the largest difference in results for beams of series A and C.

- The slightest difference was encountered when comparing results of shrinkage-treated beams versus beams treated during crawling.

- It is noted that, after deflection, the distance between the cracks and their development on the beams is more regular and denser on beams of self-compacting concrete indicating more homogeneous work in the entire length of these beams.
- Greater deflective force is required on beams of self-compacting concrete.

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