

# ANALYSIS OF THE COLUMNS OF NOISE BARRIER CONCRETE WALLS BY FINITE ELEMENT METHOD

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## Abstract

*The paper deals with numerical modelling of behaviour of reinforced concrete columns with standard reinforcement, prestressing and with dispersed steel fibres. The differences are shown in the graphs with relation of the force and deflection. The types of failure are discussed. Columns of noise barrier walls were modelled by means of nonlinear ATENA Engineering 3D software. The results are compared to the experimental results from load – deflection tests.*

**Keywords:** steel fiber reinforced concrete columns, noise barrier concrete walls, FEM modelling

## 1. Introduction

Columns have a cross section of I shape with a height of 350 mm and width of 250 mm and overall length are 2850, 3050 and 3250 mm. They are modeled as a cantilever for 2250 mm lengths of three different types of materials : steel reinforced concrete, prestressed concrete and prestressed steel fibre reinforced concrete. They were loaded with a force located 300 mm from the free end and stuck to the footing on the 600, 800 or 1000 mm. Reinforced concrete pillars are reinforced with six profiles 12 mm (three bars are in each flange of the I-section), three 10 mm profiles (the web) and as shear reinforcement stirrups are used C-shaped profile of 8 mm. Prestressed steel fibre reinforced concrete columns and prestressed plain concrete columns have two prestressing cables, one in each flange, no other reinforcement (except spacers and wires in prestressed steel fibre reinforced concrete column) is used. The results of the behavior of columns are presented in the form of charts of the applied force and deflection monitored in the place of the force. Used concrete was C35/45 and steel B505B, in the prestressed concrete columns also C35/45 concrete and prestressing strands 1770S7 Y - 15.7 – A, SFRC columns also made of concrete C35/45 and prestressing cables Y 1770S7 - 15.7 - A and steel fibers Fibrex. Stress in the prestressing cables was 1375 MPa, ie. prestressing force was 206.5 KN. Footings for all types of columns were from C30/37 concrete and steel B505B. Footing reinforcement consists of longitudinal bars and transverse shear stirrups both profile 10 mm (arrangement of longitudinal bars, wires and transverse shear reinforcement of columns is shown in Figures 2 and 3).

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Tab. 1 Properties of steel fibres

	b (mm)	h (mm)	l (mm)	f <sub>stm</sub> (MPa)
Fibres Fibrex	0,6	0,4	25	450

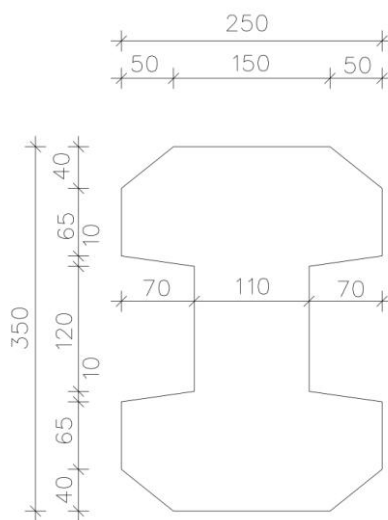


Fig. 1 : Dimensions of cross-section of pillar of noise walls

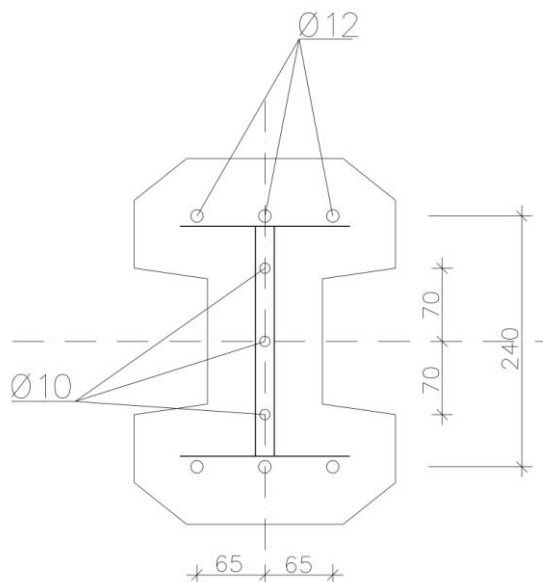


Fig 2 : Arrangement of longitudinal bars and transverse shear reinforcement of reinforced concrete column

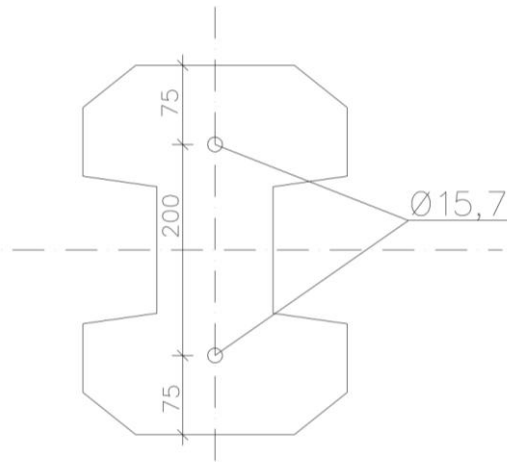


Fig. 3 : Arrangement of prestressing cables of prestressed concrete column and prestressed steel fibre reinforced concrete column

## 2. Results

### 2.1 Reinforced concrete column

Reinforced concrete column is woven into the footing with a height of 600 mm. Properties of the concrete are shown in Table 2. The first crack deflection was 0.4 mm and force 1,683 KN, the first crack width exceeded 0.2 mm at 7.2 mm deflection and force of 15.64 KN. Maximum force was achieved at 40.0 mm deflection and the value of 33.0 KN. Greatest width of cracks at maximum force was 2.12 mm. Dependence of deflection on the applied force is shown in Figure 4.

Tab. 2 Properties of concrete of reinforced concrete column

Property of concrete	Value
Modulus of elasticity	27000 MPa
Compressive strength	48 MPa
Tensile strength	1,5 MPa
Fracture energy	0,075 KN/m
Specific weight	2140 kg/m <sup>3</sup>

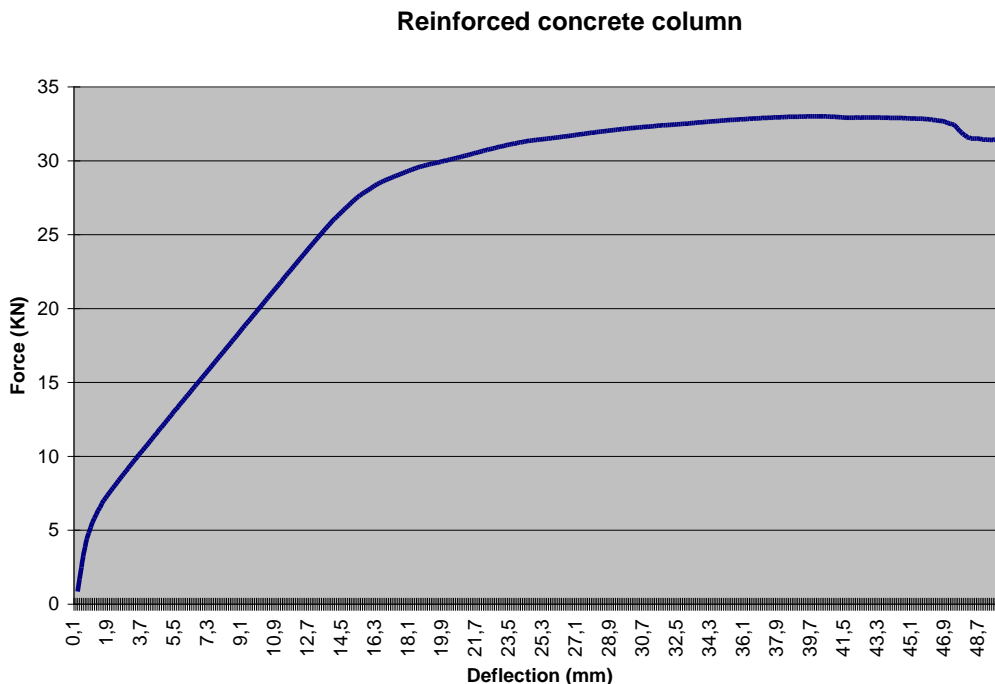


Fig. 4 : Dependence of deflection on the applied force of reinforced concrete column

## 2.2 Prestressed concrete columns

Prestressed concrete columns are woven into the footing with a height of 600 mm, 800 mm and 1000 mm.

### Column woven to 600 mm:

Properties of the concrete are shown in Table 3. The first crack deflection was 2 mm and force 19.27 KN, the first crack width exceeded 0.2 mm at 5.3 mm deflection and force of 36.04 KN. Maximum force was achieved at 25.5 mm deflection and the value of 45.05 KN. Greatest width of cracks at maximum force was 3.35 mm. Dependence of deflection on the applied force is shown in Figure 5.

Tab. 3 Properties of concrete of prestressed concrete column

Property of concrete	Value
Modulus of elasticity	37700 MPa
Compressive strength	82,7 MPa
Tensile strength	2,55 MPa
Fracture energy	0,078 KN/m
Specific weight	2450 kg/m <sup>3</sup>

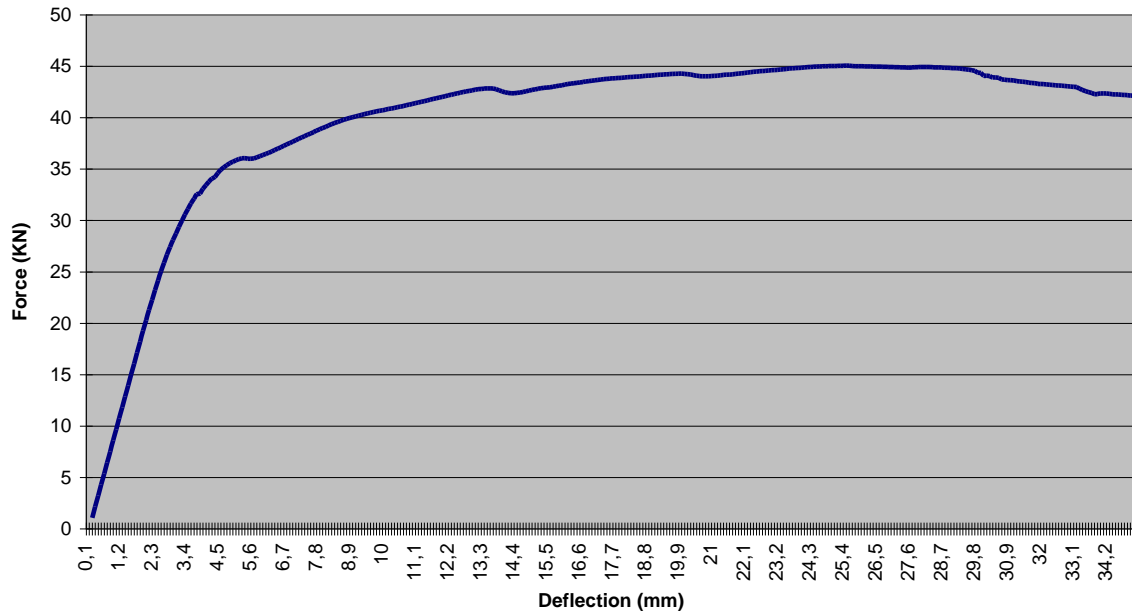
**Prestressed concrete column woven to 600 mm**


Fig. 5 : Dependence of deflection on the applied force of prestressed concrete column woven to 600 mm

Column woven to 800 mm:

Properties of the concrete are shown in Table 4. The first crack deflection was 2 mm and force 19.65 kN, the first crack width exceeded 0.2 mm at 5.8 mm deflection and force of 38.81 kN. Maximum force was achieved at 25.2 mm deflection and the value of 45.88 kN. Greatest width of cracks at maximum force was 2.43 mm. Dependence of deflection on the applied force is shown in Figure 6.

Tab. 4 Properties of concrete of prestressed concrete column

Property of concrete	Value
Modulus of elasticity	39500 MPa
Compressive strength	81,5 MPa
Tensile strength	2,35 MPa
Fracture energy	0,1029 kN/m
Specific weight	2440 kg/m <sup>3</sup>

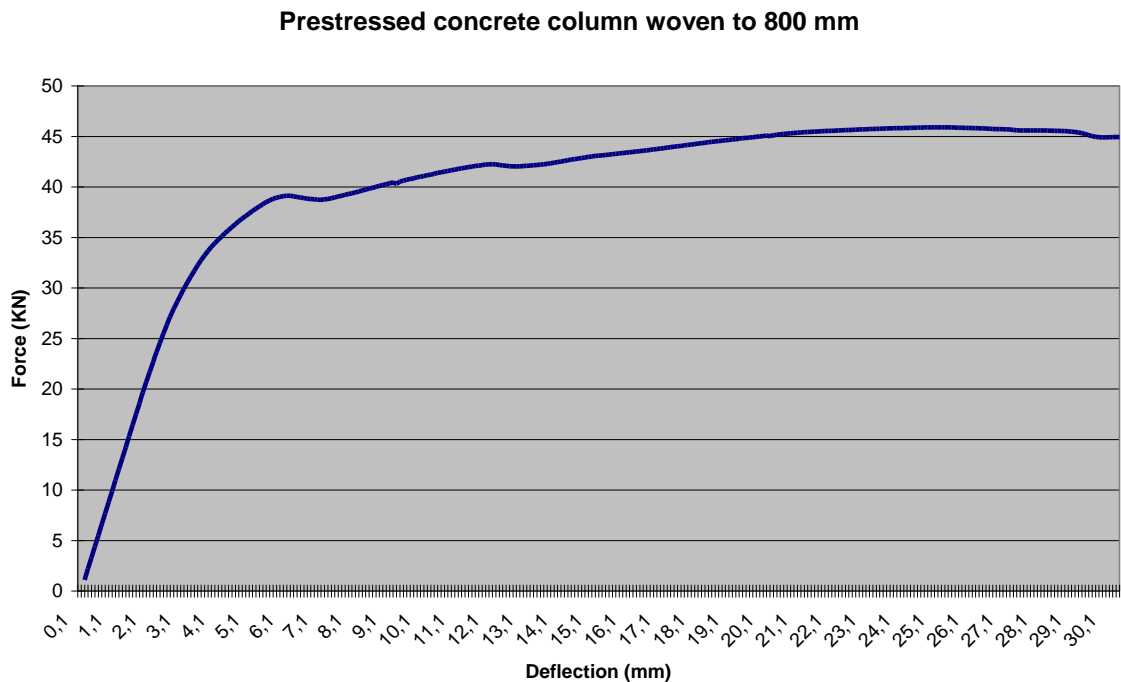


Fig. 6 : Dependence of deflection on the applied force of prestressed concrete column woven to 800 mm

Column woven to 1000 mm:

Properties of the concrete are shown in Table 5. The first crack deflection was 1,9 mm and force 18.14 KN, the first crack width exceeded 0.2 mm at 6.5 mm deflection and force of 39.08 KN. Maximum force was achieved at 27.3 mm deflection and the value of 47.38 KN. Greatest width of cracks at maximum force was 3.67 mm. Dependence of deflection on the applied force is shown in Figure 7.

Tab. 5 Properties of concrete of prestressed concrete column

Property of concrete	Value
Modulus of elasticity	39500 MPa
Compressive strength	83 MPa
Tensile strength	2,1 MPa
Fracture energy	0,0939 KN/m
Specific weight	2440 kg/m <sup>3</sup>

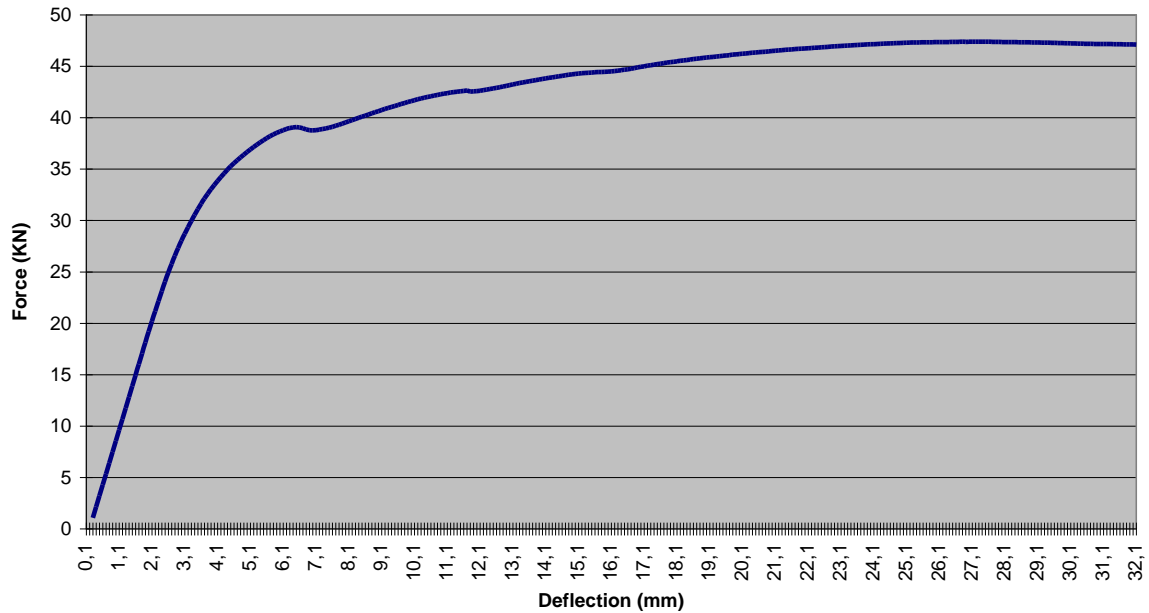
**Prestressed concrete column woven to 1000 mm**


Fig. 7 : Dependence of deflection on the applied force of prestressed concrete column woven to 1000 mm

### 2.3 Prestressed steel fibre reinforced concrete columns

Prestressed steel fibre reinforced concrete columns are woven into the footing with a height of 600 mm and 800 mm.

#### Column woven to 600 mm:

Properties of the concrete are shown in Table 6. The first crack deflection was 1,7 mm and force 19.22 KN, the first crack width exceeded 0.2 mm at 8.2 mm deflection and force of 48.91 KN. Maximum force was achieved at 28.4 mm deflection and the value of 55.96 KN. Greatest width of cracks at maximum force was 2.20 mm. Dependence of deflection on the applied force is shown in Figure 8.

Tab. 6 Properties of concrete of prestressed steel fibre reinforced concrete column

Property of concrete	Value
Modulus of elasticity	43000 MPa
Compressive strength	84,5 MPa
Tensile strength	2,35 MPa
Fracture energy	1,55 KN/m
Specific weight	2450 kg/m <sup>3</sup>

Prestressed steel fibre reinforced concrete column woven to 600 mm

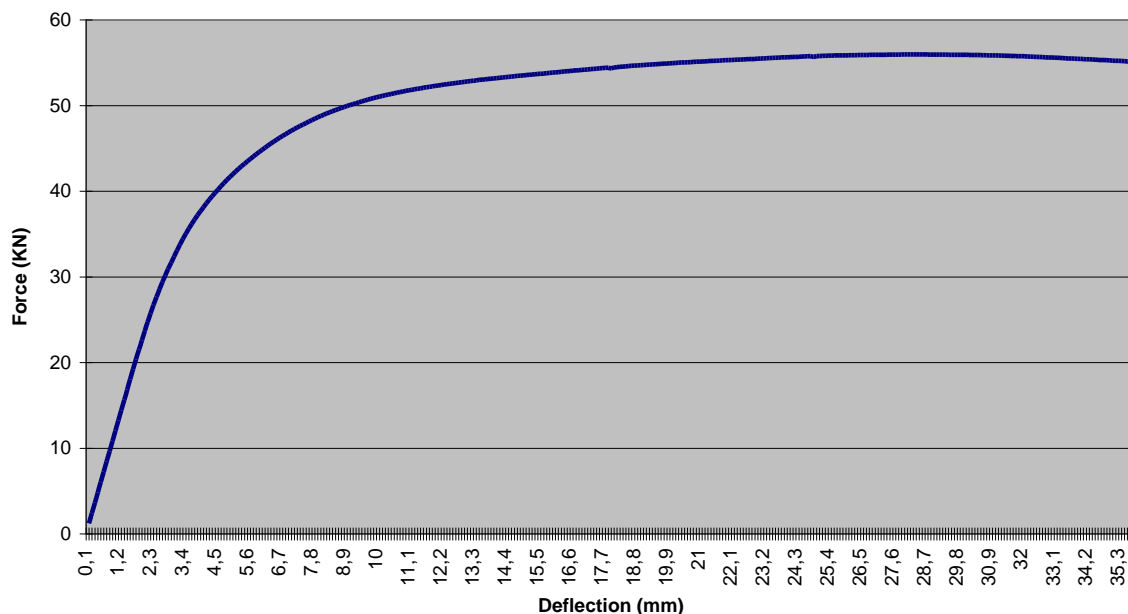


Fig. 8 : Dependence of deflection on the applied force of prestressed steel fibre reinforced concrete column woven to 600 mm

Column woven to 800 mm:

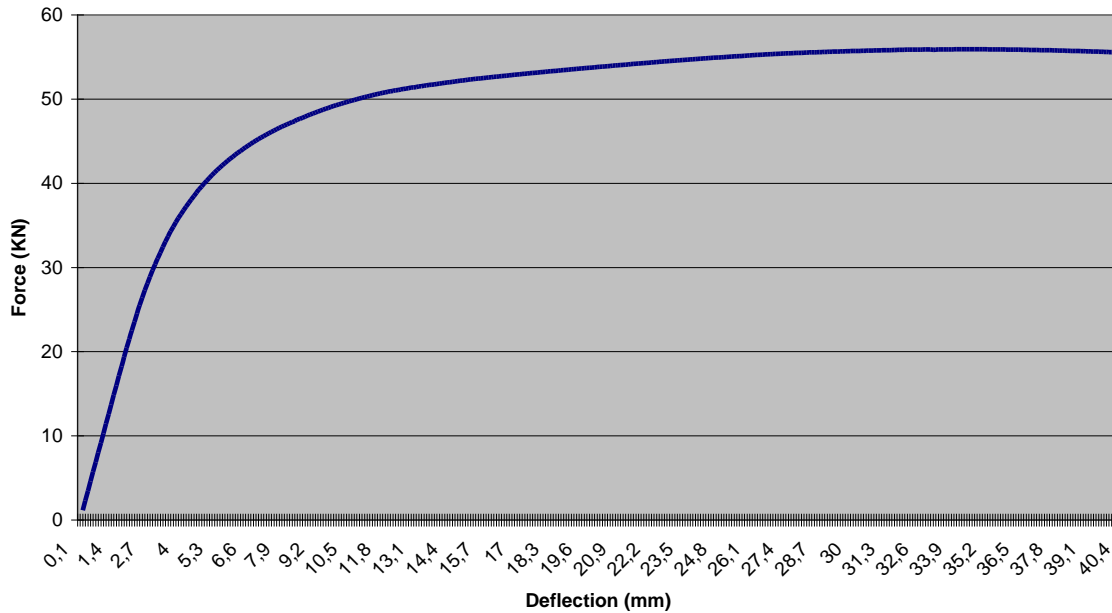
Properties of the concrete are shown in Table 7. The first crack deflection was 1,8 mm and force 18.25 KN, the first crack width exceeded 0.2 mm at 7.1 mm deflection and force of 45.25 KN. Maximum force was achieved at 34.6 mm deflection and the value of 55.91 KN. Greatest width of cracks at maximum force was 2.34 mm. Dependence of deflection on the applied force is shown in Figure 9.

Tab. 7 Properties of concrete of prestressed steel fibre reinforced concrete column

Property of concrete	Value
Modulus of elasticity	41500 MPa
Compressive strength	87,5 MPa
Tensile strength	2,1 MPa
Fracture energy	1,55 KN/m
Specific weight	2480 kg/m <sup>3</sup>



**Prestressed steel fibre reinforced concrete column woven to 800 mm**



*Fig. 8 : Dependence of deflection on the applied force of prestressed steel fibre reinforced concrete column woven to 800 mm*

### 3. Conclusions

It is obvious that prestressing and a higher class of concrete led to increased resistance of prestressed concrete columns compared to reinforced concrete column. Differences between columns with different lengths of restraint are not large. Maximum force 45.05, 45.88 and 47.38 KN at deflections of 25.5, 25.2 and 27.3 mm, were for restraint 600, 800 and 1000 mm respectively. Maximum force in prestressed steel fibre reinforced concrete columns was at the length of the restraint 600 and 800 mm 55.96 and 55.91 KN and deflection at 28.5 and 34.6 mm. More interesting is the difference between prestressed concrete and SFRC columns, where load bearing capacity is increased by added steel fibers. The values of deflections and force applied during formation of the first cracks are still the same and that between 1.8 and 2 mm and 18 and 20 KN. Comparison of columns is summarized in following table.

Tab. 8 Comparison of columns

Construction type of column/ length of restraint	First crack		Crack width 0,2 mm		Maximum force	
	Deflection (mm)	Force (KN)	Deflection (mm)	Force (KN)	Deflection (mm)	Force (KN)
Reinforced concrete	0,4	1,683	7,2	15,64	40	33
Prestressed 600 mm	2	19,27	5,3	36,04	25,5	45,05
Prestressed 800 mm	2	19,65	5,8	38,81	25,2	45,88
Prestressed 1000 mm	1,9	18,14	6,5	39,08	27,3	47,38
Prestressed SFRC 600 mm	1,8	19,22	8,3	48,91	28,5	55,96
Prestressed SFRC 800 mm	1,8	18,25	7,1	45,25	34,6	55,91

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### References

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