

The Creep Effect in Reinforced Concrete Deep Beams for a Structural Floor

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Abstract: It is well known the effect that the creep effect has on reinforced concrete structures. As a result of load action through time, the structures undergo deformations as well as variation in the internal forces. In this article, we studied the performance of the creep effect likewise the evaluation of internal forces in the interstorey beams of the first floor, for 12 stores building, with a reinforced concrete structures, for architectural reasons they will support the columns of the above floors. This study will rely on finite elements numerical model of the object.

Keywords: creep effect, displacements, bending moment, shear force.

1. Introduction

The creep effect is present in all kind of materials, but his effect is negligible in steel structures, while in the reinforced concrete structures has to be taken under account. The creep effect in concrete structures has been studied for the first time by Woolson in 1905[3], and from there on by many authors. Among the effects of this phenomena are the variation in internal forces that the structure undergoes in time. Theoretically, deformation caused by the creep effect are the result of the water molecules chemically bound to the concrete shifting as a result of load action in time. These deformations are greater the first few years after the construction of the building and decrease progressively until they reach a limit value. The study of the creep effect in reinforced concrete structures is very important, especially in regard to the deformation or even the variation in internal forces.

2. Objectof the Study

The objects of this study are the interstorey beams of the first floor of a 12 storey building, which support the columns of the upper stories. The structure is designed with C25/30 concrete class. For comparison, the study will also be designed with C30/37 concrete class, as a request of the investor.

The 12 storeys building have 2 underground storeys and 10 aboveground storeys. It is a multifunction building: housing, service and offices. The total height of the building is $H_b=39.45$ m. The two underground storeys will be used as parking, and have a storey height of $h_s=3.3$ m, the first storey which will have service functions, will have a height of $h_s=4.5$ m, while the other 9 floors which will be used as residential $h_s=3.15$ m

The singularity of this building is that the first interstorey (+4.50m above ground), for architectural purposes will support the columns in axes D-2, D-3, D-4, as a result of plan differences between floors.

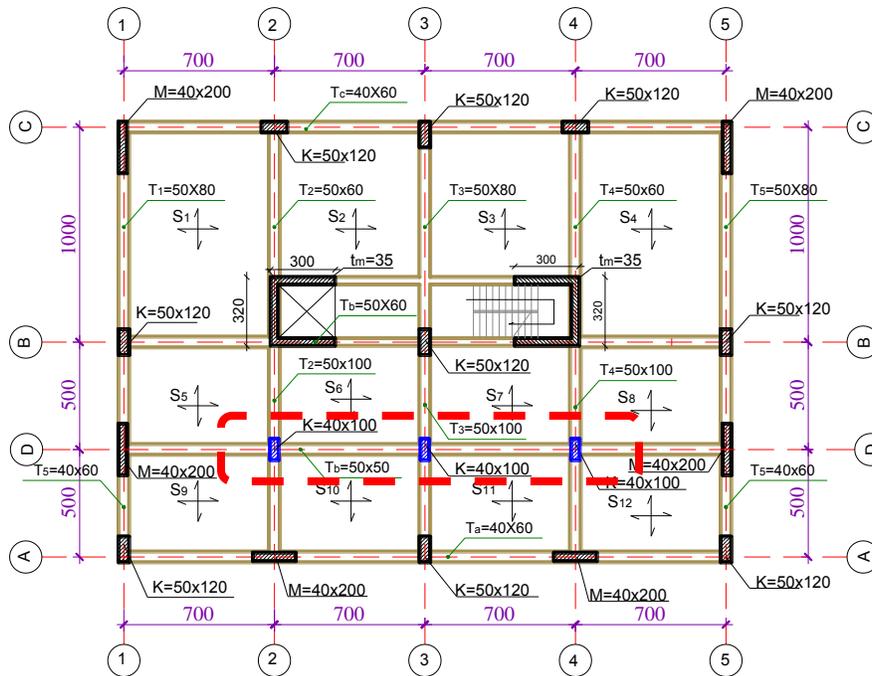


Fig. 1: Structural plan of the interstorey +4.50 m

From storey -6.60 m to storey +4.50 m, there is a structural system with four spans $L_x=7$ m in the “X” direction and two spans with $L_y=10$ m in “Y” direction. From +4.50 m to +33.45 m, the system structure is with four spans $L_x=7$ m in the “X” direction and with two different spans $L_{y1}=10$ m, $L_{y2}=5$ m in “Y” direction.

The interstorey of the building at +4.50 is designed with a monolithic slab (r.c slab), of 20 cm thickness and deep beams of 30x50cm, 40x60cm, 50x50cm, 50x80cm, 50x100cm dimensions, while the above floors are designed with two way slabs (with lighten bricks slab) of 30 cm thickness and beams with dimensions 70x30cm, 30x50cm, 40x60cm.

The aim of our study is to determine the deformation and the variation in the internal forces as a result of the creep effect in the beams of the above mentioned interstorey, with dimensions of 50x100cm which support the above columns.

3. Numerical Model, Creep Effect Law and Results.

3.1. Numerical Model

Calculations are based on three dimensional numerical model with finite elements, linear “beams” and “shell” type slabs modelled using a commercial software for structural analysis (SAP 2000) [5].

During the modelling of the structure, has been taken under consideration the geometry of the structural elements and the loads acting on the structure. The loads are estimated using the Albanian design code (KTP-89)

From the numerical model of the object are obtained the elastic deflection, deflection from the creep effect, internal forces of the interstorey beams when the columns are supported.

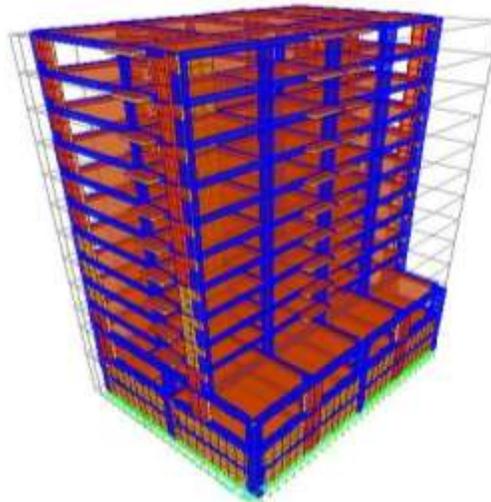


Fig. 2: Three dimensional numerical model with finite elements

3.2. Creep Effect Law

The creep effect law used in the calculations are taken from the European normative [1], [2], [4]. Referred to the above standards, the creep effect deflections are:

$$\delta_c = \delta_{e,p} * \phi(t, t_0)$$

δ_c - Deflection from the creep effect

$\delta_{e,p}$ - Elastic deflection from the combination of permanent loads.

$\phi(t, t_0)$ -Coefficient of creep effect taken from the creep effect law for concrete.

The creep effect given in figure 3, is derived from relation between the coefficient $\phi(t, t_0)$, concrete class parameters, relative humidity of the environment, geometrical parameters of the element section, average temperature and time.

For the determination of the creep effect coefficient law, was accepted as a relative humidity of 70% and relative ambient temperature 20°C. Calculations were carried out for two concrete classes, respectively C25/30 and C30/37.

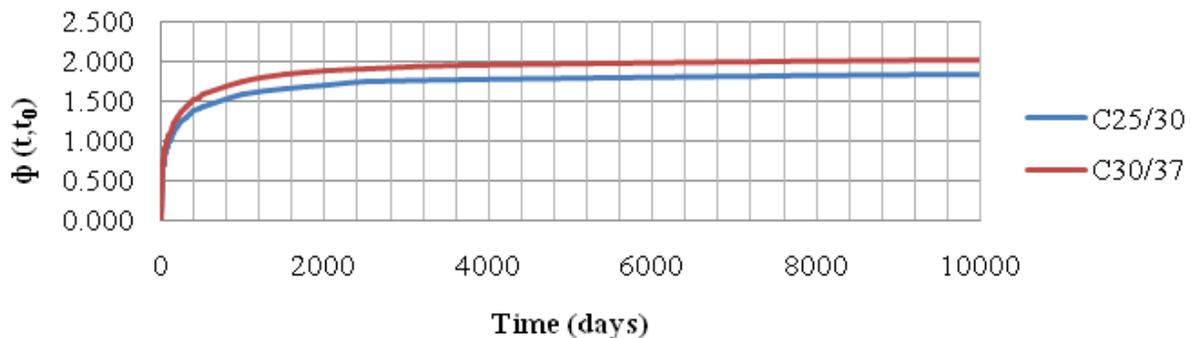


Fig. 3: Creep effect coefficient law $\phi(t, t_0)=f(\text{time})$

From the graphs, we can see that the value of the creep effect coefficient, undergoes significant increase in the first two years and then the increase is smaller while approaching a limit value. The final value (for $t = 10,000$ days) of this coefficient is respectively 2.017 for C25/30 and 1.883 for C30/37.

3.3. Results

According to data released by the calculator software, for both classes of concrete, we can take the deflections values in characteristic points of columns support. The results are presented below in a summary, in graphic forms.

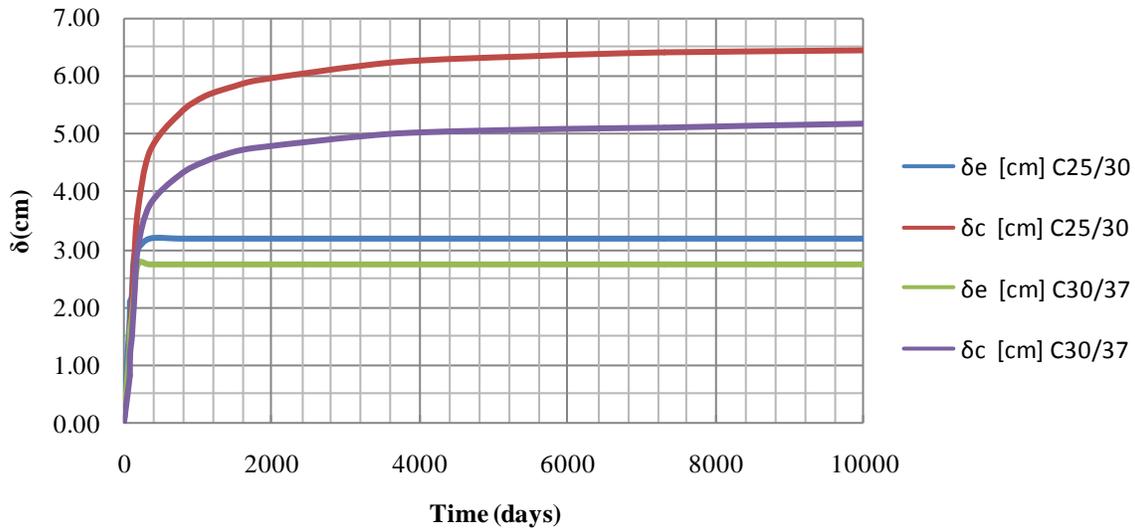


Fig. 3: Deflections in points D2 and D4, for concrete classes C25/30 and C30/37

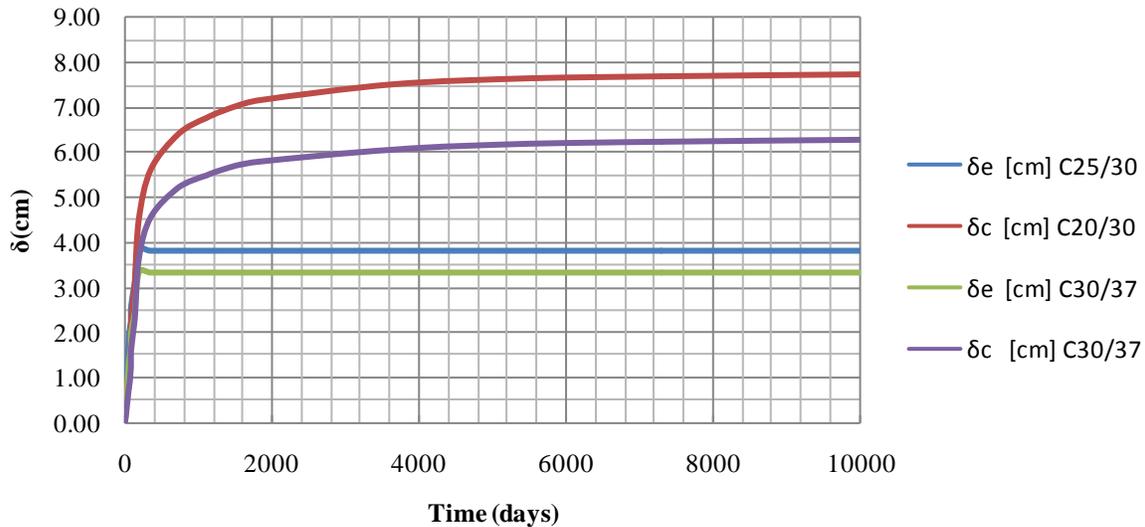


Fig. 4: Deflections in points D3, for concrete classes C25/30 and C30/37

The above results are for three characteristic points, respectively: points D2 and D4 (by symmetric axis), which are located at the intersection of the axis D to the axis 2 and 4; and point D3, which is located at the intersection of the axis D to the axis 3. In the graphs, we can see the evolution in time of the deflections (δ_c) caused by the creep effect, while elastic deflections (δ_e) reach their limit values at the time of completion of construction.

It should be noted also, that in the study is not consider the shrinkage effect of concrete, which would have made a reduction of the deflections values. Also, it is not taken into account the quantity of armature in the elements, which it will bring a reduction of creep effects. The above values can be considered to be overstated.

From hyper static structures as a whole, we can say that the creep effects, except of geometric variations (deflections), can develop also and variations in their static mode. This is noted in the values of internal forces (Moments, Shear Forces) of the interstorey beams, which undergo variations as a result of this effect.

In analyzing of the study case, are taken into account internal forces from the quasi permanent combination loads + creep effect, for beam T3 (beam at axis 3, part between the axes A and D) for two characteristic beam sections; for section S-1, positioned in the middle of the span and exactly under pinnings column and section S-2 at support beam, positioned to intersections of the A and 3 axes.

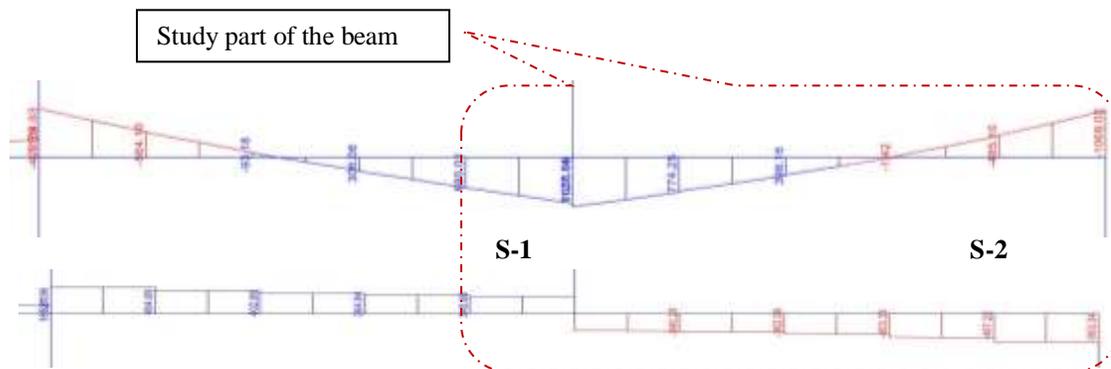


Fig. 4: Bending moment (M) and Shear Force (Q) diagrams for T₃ beam

Below are presented the variations of the values of moments and shear forces from the quasi permanent combination loads + creep effect, for two sections obtained in this study.

TABLE I: Bending moments (M) and Shear Forces (Q), for C25/30

Time [days]	M-S2	Q-S2	M-S1	Q-S1
	kN*m	kN	kN*m	kN
180	-1068.02	-563.29	1127.13	-332.69
365	-1014.78	-535.36	1180.37	-348.62
1095	-999.83	-527.31	1201.81	-353.67
1825	-995.12	-524.40	1203.03	-354.58
3650	-993.20	-523.57	1205.95	-355.41
5475	-991.62	-523.09	1211.53	-356.89
7300	-989.34	-521.36	1213.81	-357.62
10000	-986.57	-519.89	1215.58	-359.09

For concrete class C25/30, we can see that the value of moments in support section, ranges in time from -1068.02kN*m to -986.57kN*m while in space section, by 1127.13kN*m to 1215.58kN*m. Shear forces values in support section, ranges in time from -563.29kN to -519.89kN, while in space section by -332.69kN to -359.09kN.

TABLE II: Bending moments (M) and Shear Forces (Q), for C30/37

M-S2	Q-S2	M-S1	Q-S1
kN*m	kN	kN*m	kN
-961.57	-503.28	916.59	-274.52
-908.38	-475.33	969.78	-290.47
-899.70	-470.18	980.46	-293.62
-895.44	-468.93	983.72	-294.87
-894.88	-468.87	985.28	-295.93
-891.99	-466.78	987.17	-296.02
-888.05	-464.24	988.11	-296.11
-885.57	-461.94	990.59	-297.86

For concrete class C30/37, we can see that the value of moments in support section, ranges in time from -961.57kN*m to -885.57kN*m while in space section, by 916.59kN*m to 990.59kN*m. Shear forces values in support section, ranges in time from -503.28kN to -461.94kN, while in space section by -274.52kN to -297.86kN.

Considering the absolute values, the variation in time of the internal forces due to creep effect, graphically will appear:

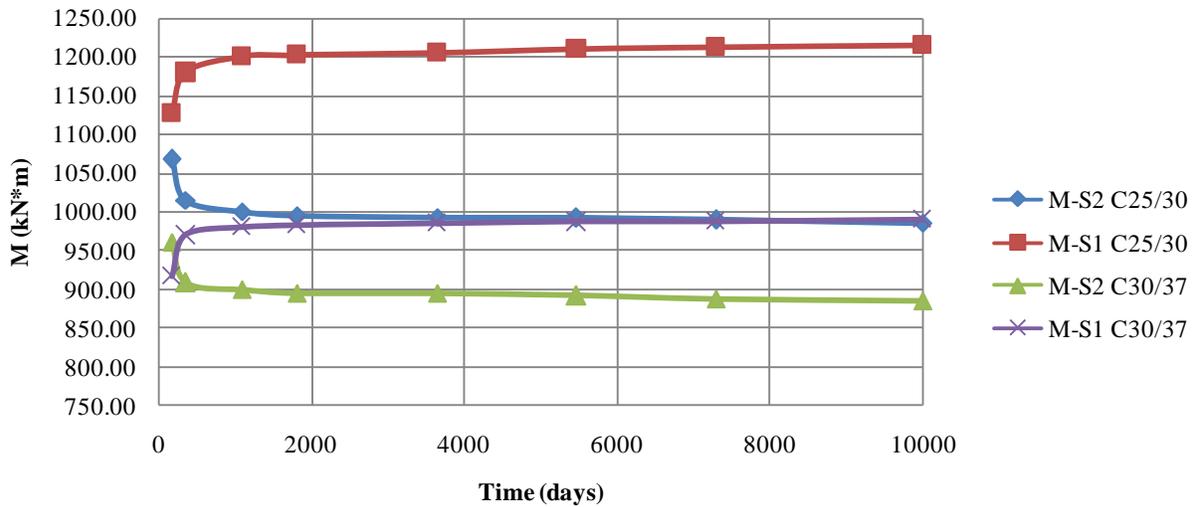


Fig. 5: Variation on the time of absolute values to the moments, for sections S1 and S2; as well as concrete grade C25/30 and C30/37

As for shear forces, will have:

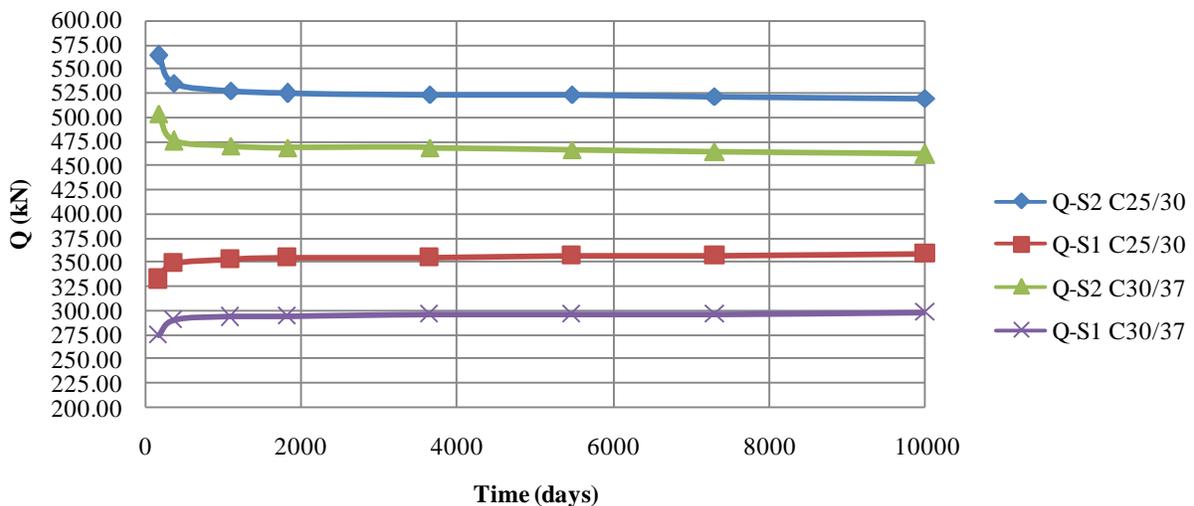


Fig. 6: Variation on the time of absolute values to the shear forces, for sections S1 and S2; as well as concrete grade C25/30 and C30/37

From the above tables and graphs, the values of moments in support section, fade in time, while in middle span section, increase. Also, the variation of shear forces values Q, decreases to support section and increases in middle span section. So, we have redistribution of internal forces due to the creep effect.

4. Conclusions

1. The creep effect deflections, at the end of first year, reach approximately 70% of the total deflections from this effect;
2. The internal forces from creep effect, vary in the range of 7-9%;

3. Within crease concrete class, from C25/30 to C30/37, the creep effect deflection reduces around 15-20%;
4. Within crease concrete class, from C25/30 to C30/37, the internal forces taking in account the creep effect, reduce around 10-18%;
5. As result of the creep effect, internal forces vary and are redistributed with their respective values.

5. References

- [1] EN1992-1-1 (2004). Euro code 2: Design of Concrete Structures. Part 1-1: Gen. Rules and Rules for Buildings.
- [2] Guida all'uso dell'Eurocodice 2 " Progettazione di strutture in C.A " Vol I+II
- [3] A.Migliacci , F.Mola "Progetto agli stati limite delle strutture in C.A "Vol I+II
- [4] CEB-FIP Model Code 1990, Design Code
- [5] "SAP2000 v.15" – Analysis Reference Manual.