Structural Engineering

INTERSECTII
INTERSECTIONS
http://www.intersections.ro

Design of large sized floors

Ludovic Kopenetz, Alexandru Cătărig, Titu Hodişan
Department of Civil Engineering, Technical University of Cluj-Napoca, 400020, Romania

Summary

The large sized floors can frequently be found in multistory car parks structures, bank buildings and industrial buildings. These floors, whose plan dimensions are between 30x30 square meters and 50x50 square meters (or larger) , need special attention considering the deformation of the structural concrete and the function of the building. The paper presents some aspects of the structural analysis that the structural designers have to consider.

KEYWORDS: floor, slab, structure system, drying shrinkage, concrete, reinforcement, tensile unit strain, salt water, oil, chlorides.

1. INTRODUCTION

The growth rate of our country's economy has been, for the last years, above 8%. In the field of civil construction the rise is over the mean value of the national economy. This has led to the appearance of large dimension structures.

Unfortunately a lot of these structures have shown delicate structural problems, as for example: cracks, flaws, in many cases, in the horizontal load resisting system (floors) (Fig.1,2,3).

Overground and underground parking structures belong to this category, [1], [2]. There are a lot of large span parking structures in combination with other facilities like: flats, offices, markets, placed on the upper levels.

The main structural material for these structures is the reinforced concrete and such will be the case in the following years due to the use of high resistance concrete, [3].

Structural system selection should satisfy strength, flexibility, durability, easy maintenance to vertical and horizontal loads. If the vertical load structure selection is not difficult because of the multiple structural alternatives (frames, frames with structural walls, tube systems), the horizontal load structure selection requires special analysis because of the large spans.

Structural Engineering
INTERSECTII
INTERSECTIONS
http://www.intersections.ro

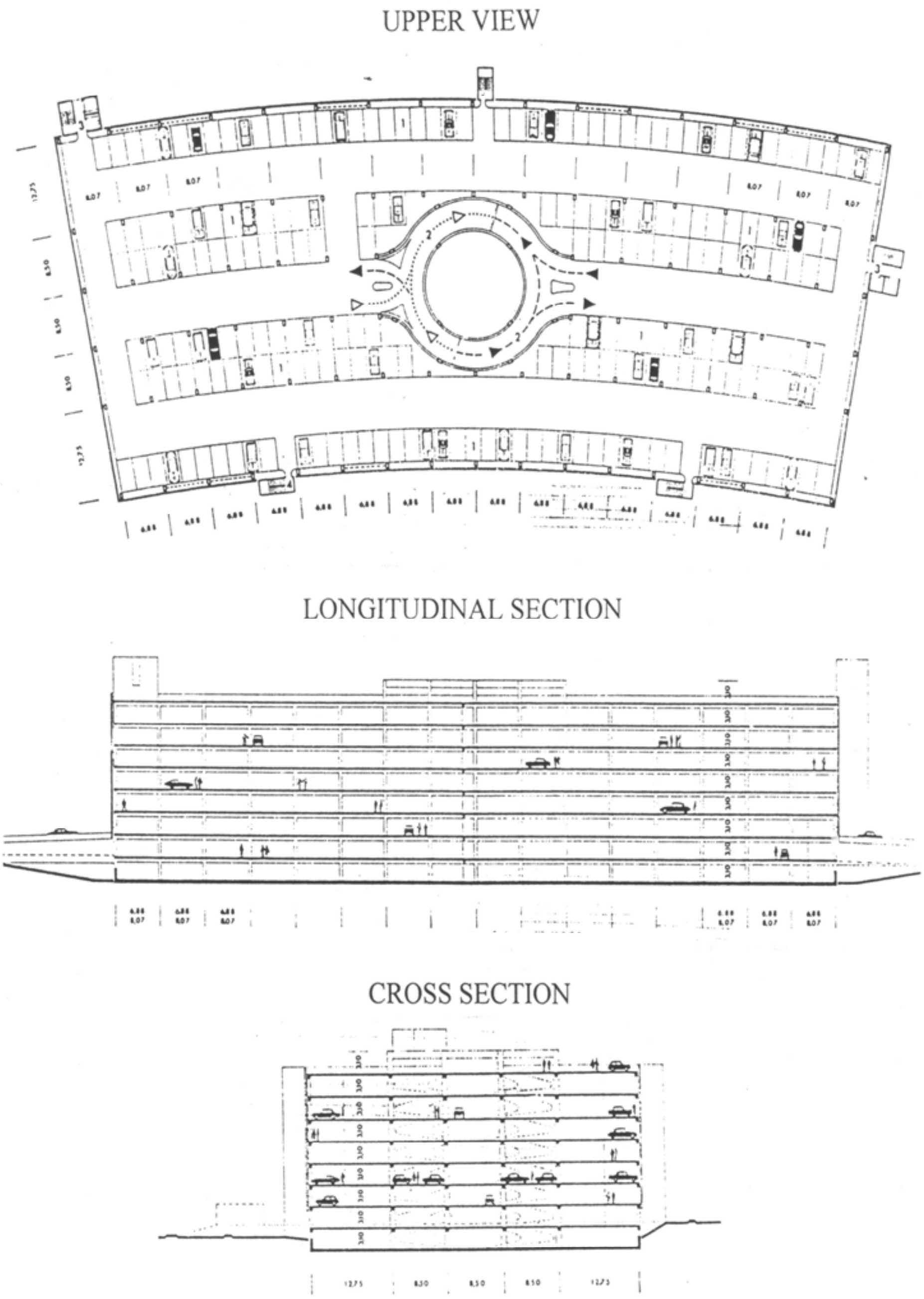

Figure 1

ISSN 1582-3024

INTERSECTII
http://www.intersections.ro

2. STRUCTURAL ANALYSIS

The selection of the structural system is influenced by the basic function of the building. As compared with the constructions of the 80's and the 90's today large span construction (2500-3000*sqm*) prevail. An important problem appears in the case of high values of the axial forces engendered by the vertical loads (even in case of live load of 200*daN/sqm*).

The selection of the structural system is also influenced by horizontal displacements which must fulfill the condition

$$\frac{\Delta_r}{H_e} \leq 0{,}007 \qquad (1)$$

where:

- Δ_r is the relative level displacement excluding nonstructural walls,

- H_e is the height of the level.

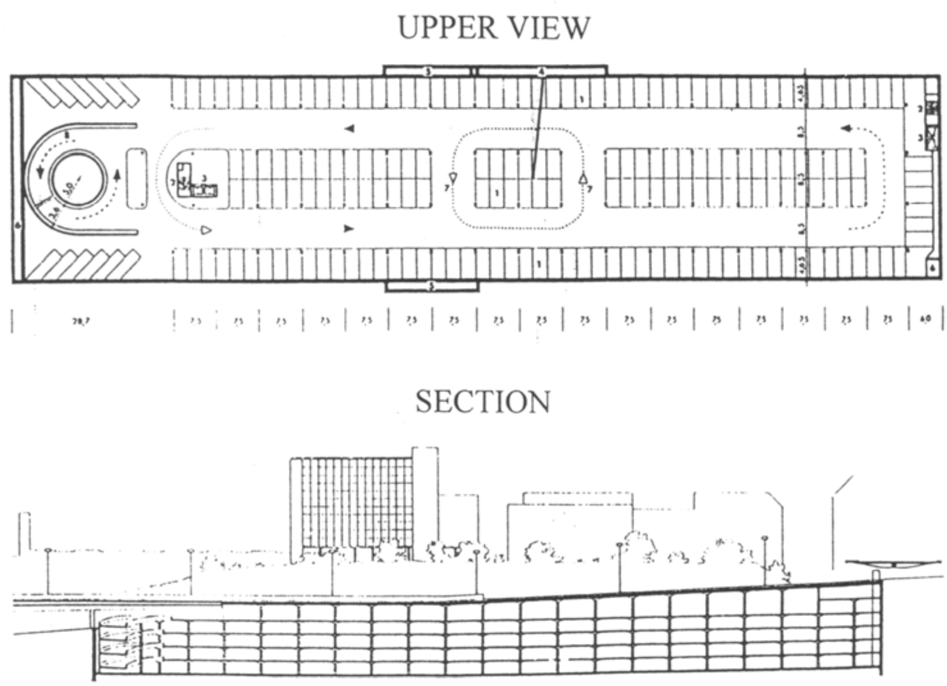

Figure 2

ISSN 1582-3024

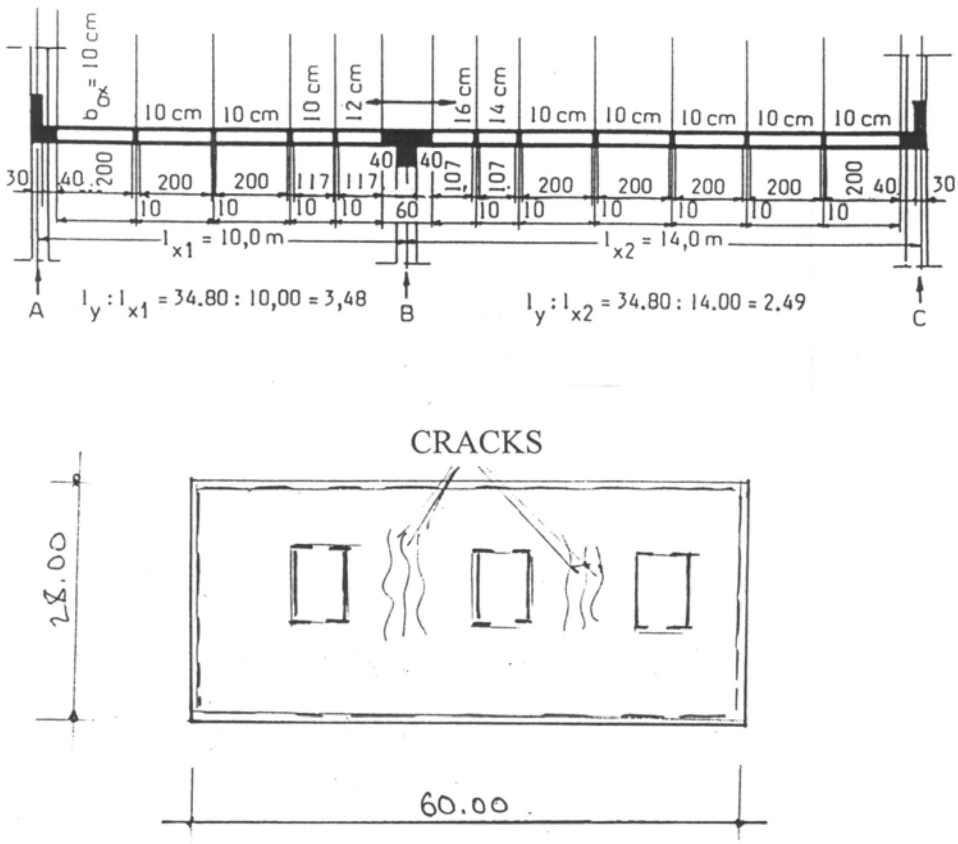

Figure 3

Note: This condition for displacements is applicable in the case of buildings with deformable wall panels.

The horizontal load resisting system consists of ceilings with bays, slabs on beams and girders and slabs on columns with prestressed or nonpresstresed reinforcement. In the case of nonpresstresed reinforcement in areas with big tensile stress, cracks appear.

Considering the great width of the slab due to the large spans (15 – 25m), the value of drying shrinkage is $\varepsilon_c = 0{,}6$ ‰.

ISSN 1582-3024

Structural Engineering

INTERSECTII
INTERSECTIONS
http://www.intersections.ro

This value is much bigger than the value given by STAS 10107/0-9, [5], ($\varepsilon_c = 0{,}2 - 0{,}3$ ‰) 400% bigger than the maximum concrete tensile strain ($\varepsilon_t = 0{,}15$ ‰).

In structural analysis, the use of the equation of drying shrinkage with a variation of a temperature $\Delta t = -10^0$ is a fundamental error because none of the effects can be considered similar even formally, [4]. Thus, considering the variation of temperature, both concrete and reinforcement shrink. In the case of drying shrinkage, only concrete does.

Note: Existing software programs are not able to observe these aspects.

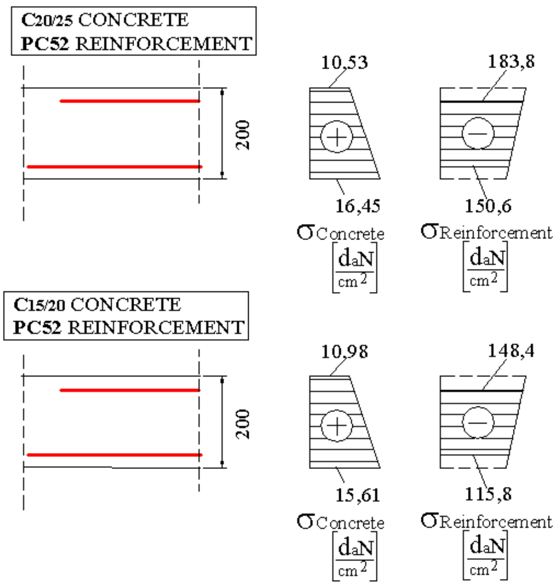

Figure 4 - Stresses in a slab of large dimensions. Concrete of different classes and similar reinforcement

In the case of drying shrinkage there appears a change of the induced stress, even to exterior statically determinate structures. Considering the relaxation of concrete these phenomena are balanced in time, but for the green concrete they are extremely dangerous. For the calculation of the induced stress of drying shrinkage, several methods can be applied such as Trost, Dischinger- Fritz, or the practical method.

If considering a reinforced concrete linear element:

$$\varepsilon = \varepsilon_c - \varepsilon_{bt} = \varepsilon_a \qquad (2)$$

where:

ISSN 1582-3024

- ε is the unit strain of the linear element,
- ε_c is the initial drying shrinkage unit strain,
- ε_{bt} is the concrete tensile unit strain,
- ε_a is the reinforcement unit strain.

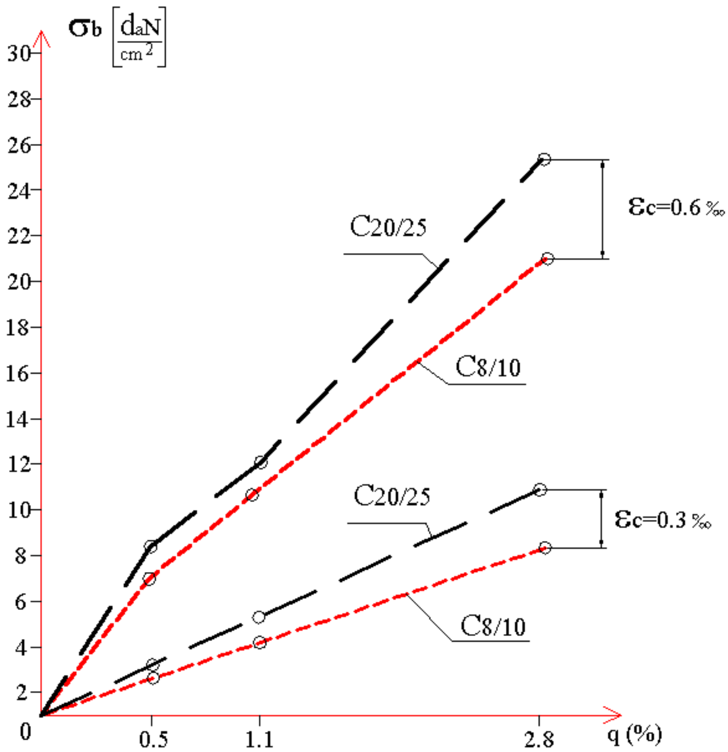

Figure 5 - Compression stresses in a RIC beam with Symmetrical reinforcement versus concrete class, contraction coefficient and reinforcement percentage.

As concerns the application of the relation (2), in figures 4,5,6 are shown the values of drying shrinkage stresses, considering the value of drying shrinkage unit strain $\varepsilon_c = 0{,}6\,‰$ and $\varepsilon_c = 0{,}3\,‰$ for different qualities of concrete and reinforcement percentage.

ISSN 1582-3024

3. THE IMPACT OF SALT WATER AND OF OIL IMBUING ON THE HORIZONTAL RESISTING SYSTEM

In the case of multilevel parking the influence of salt water and oil on the horizontal resisting system is a serious problem.

In winter cars leave snow on the floors and sometimes oil drips. The cracking state ot the superior part of the floor in column zones above beams and girders will allow the migration of the salt water and oil in the structure.

The effect of salt water is the corrosion of the reinforcement (rust foil) and the presence of chlorides above normal values (300-500*mg/kg*), in the concrete.

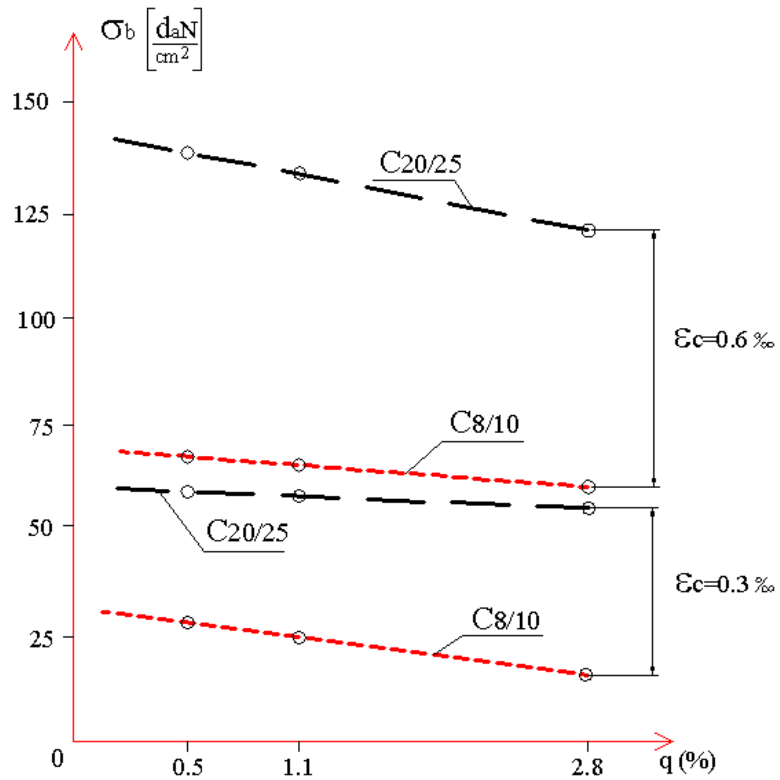

Figure 6 - Tension stresses in the reinforcement of symmetrically reinforced beam versus concrete class, contraction coefficient and reinforcement percentage.

ISSN 1582-3024

The presence of chlorides speeds the corrosion of the reinforcement, leading to its disappearance (it is a self propagating process in progress as long as there steel exists).

In combination with the calcium hydroxide [$Ca\ (OH)_2$] in the concrete, oil produces salts (non resistant) and if this is on a long term the concrete resistance decreases.

If these zones coincide with bending pressure zones in beams and slabs, there is considerable shrinkage because the resistance of concrete is diminished and cracks open in the stretched zones.

4. CONCLUSIONS

* Initial tensile stresses of concrete and pressure stresses of reinforcement are proportional with the concrete quality, in the case of a strong reinforcement (Fig.4).

* Initial tensile stresses of concrete are proportional with the reinforcement percentage, with concrete quality and with the drying shrinkage unit strain (Fig.6).

* Initial pressure stresses of reinforcement are in inverse ratio to the increase of the reinforcement percentage and proportional with the quality of the concrete.

* It is necessary to take special measures to diminish the effects of the shrinkage of the concrete.

References

1. CEB-FIP (1990), Model code for concrete structures (MC-90), CEB Thomas Telford, London, 1993.
2. ACI – COMMITTEE 109 (1992), Prediction of creep, shrinkage and temperature effects in concrete structures – 209R-92,ACI, Detroit, Michingan.
3. Paulay, T., Priestley, M.I.N., *Proiectarea structurilor din beton armat la actiuni seismice*. Editura Tehnica, Bucureşti, 1997.
4. Eurocode 2 (1991), Design of concrete structures, European Prestandard, ENN 1992-1, 1991E, Brussels, Belgium.
5. STAS 10107 / 0 -90, Calculul si alcatuirea elementelor structurale din beton armat si beton precomprimat.
6. Herczeg, K., Gepkocsi parkolok, muszaki, konyvkiado, Budapest, 1978.
7. Dabija, F., Vierescu, R., Proiectarea structurala a cladirilor pentru parcaje, Buletin AICPS, nr.4, 1999.

ISSN 1582-3024