INFLUENCE OF CONCRETE MATRIX CREEP AND SHRINKAGE ON PERFORMANCE OF STEEL-CONCRETE COMPOSITE PRESTRESSED STRUCTURAL MEMBERS SUBJECTED TO LONG-TERM LOADS

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Introduction

The actual concern for structural engineers is the failure of the structural material to meet the design safety and the safe service life of large span and wide floor space buildings including modern industrial buildings, warehouses, aircraft hangers requiring more and more free and clear spaces.
To satisfy this requirement for spans exceeding 18 m steel-concrete composite precast and prestressed trusses accommodating composite precast and prestressed roof slabs and supported by composite columns as shown in Fig.1 are more suitable and more economical comparably to our traditional timber trusses covered by steel roof sheets and supported by timber columns with regards to termites' attack and corrosion.
Many previous theoretical and experimental studies have shown that the use of steel-concrete composite is effective to improve the stiffness of the structural material, predicting the eventual progressive cracking characteristics of the structural composite members. Design formulas for stress-strain limit states of the composite structures have been previously proposed based on specific experiments. However, little evaluations of time effects provided by the stretching of the high strength steel tendons, and by the long-term static, and quasi-static loads of the structural members have been conducted. But few original research works concerning the long-term deflections due to creep, shrinkage, fatigue in the above said structural composite elements, predicting the stiffness, strength, reliability, durability, fatigue, life safety, stability, and the progressive cracking of these said composite members have been really conducted.
The main research objective in this present report relates to the influence of the concrete matrix creep and shrinkage and also the tendons' prestressing losses on the performance of the above said steel-concrete composite precast and prestressed trusses, columns and slabs.
Force equilibrium and deformation compatibility protocols have been observed at all stages of calculations.
The need to validate the theoretical results, required detailed planning of series of controlled experiments including (a) calibrating the parameters likely to enable the estimation of the time-dependent prestressing losses, (b) predicting the members sections' stiffness and strength by determining the long-term flexural and non-linear creep capacity of the cracked and non-cracked sections and hence, (c) devising a definition for structural durability and integrity, with regards to the concrete matrix stress-strain relationship under long-term service loads.

Theoretical Concepts

The conceptual aspect of the composite trusses depends generally on the shape of the roof and its general lay out. The most favourable concept of the top chord is obtained in the bow string composite trusses shown in Fig. 1 accommodating roof reinforced precsat and prestressed concrete slabs. The web vertical and diagonal members are subjected to forces of lower magnitude, whereas the bottom chord is subjected to very heavy tension, for its section should be adequate to accommodate the prestressing tendons.

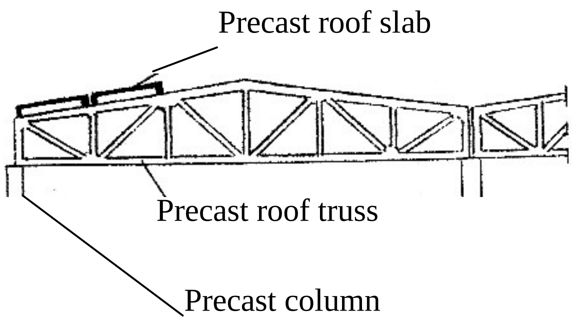

Fig. 1 Steel-concrete composite precast and prestressed roof trusses accommodating roof precast slabs and supported by precast columns

For the composite columns, the main conceptual aspect is based on the well-known Euler column formula, and other concepts by Yasinskiy, Timoshenko, Vlasov, … etc and many other Authors, on the problem of quality, stiffness, strength, reliability, durability, fatigue, life safety and stability of precast and prestressed concrete struts.

For the composite slabs the main conceptual aspect is based on the well-known geometrical preconditions of the theory of elasticity concerning thin plates with small flexural deformations.

These structural composite elements should be investigated not only as the most often used prefabricated structural composite elements, but also like the most convenient models for theoretical and experimental studies, which can permit to widely and reliably reveal the positive effects and generalize them to more complicated type of structural composite elements.
The extended interests include the study of the influence of the composite material non-linearity, creep, shrinkage, integrity and the progressive cracking characteristics under long-term static, quasi-static and cyclic dynamic loads. Force equilibrium and deformation compatibility protocols have been observed at all stages of calculations.

Experimental Program

The experimental program consist of some specific subgroups (two trusses per sub-group) of twelve 2 m span steel-composite precast and prestressed trusses (with a specified characteristic material properties of 45 MPa for the concrete matrix, and Esp = 195 GPa for the high-yield steel tendons with nominal diameters of 12,9 mm and 15,3 mm which will be contained in frames made of 5 mm bent mild steel mesh with Es = 200 GPa). The composite members will be subjected to distinct but constant maintained vertical loads within a period of 6 months, and after will be tested to failure quasi-statically and under cyclic vertical and horizontal dynamic loads at the last day of the experimental agenda. The extended interest will include the investigation of the variations of the concrete matrix strains in the bottom chords and in the steel prestressing tendons.
For the evaluation of concrete matrix physical-mechanical properties, specific subgroups of 300x150∅ mm cylinders and 150 mm cubes will be tested periodically. The variation in lateral deflections influenced by concrete matrix creep and shrinkage will be monitored continuously.
At the concrete matrix age of 9 days with natural curing, all of the composite trusses, after the transfer of stresses from the prestressed steel tendons to the concrete matrix, will be compressed by the prestressing force P, will be removed from their forms and then will be taken away from the prestressing beds together with their deflection indicators, after cutting the steel tendons. Two of the composite trusses, marked T-11 with tendon nominal diameter 12,9 mm, and two other marked T-12 with tendon nominal diameter 15,3 mm after their compression by the prestressing force P will be maintained in the laboratory without long-term loads. By them will be obtained the variations of the deformations in the prestressing steel tendons and in the concrete matrix, due to prestressing force P and due to the shrinkage of the concrete matrix. Further, at the concrete matrix age of 36 days, 8 (number of) other composite trusses will be tested under long-term static constant maintained axial loads with different loading intensities.
Similarly, for the composite slabs, the experimental program consisted of casting twelve 180x180x5 cm pre-tensioned steel-concrete composite slabs with specified characteristic material properties of 45 MPa for the concrete matrix and E_{SP} = 195 GPa for the high-yield steel tendons with nominal diameter of 10 mm which will be contained in frames made of 5 mm bent mild steel mesh with E_S = 200 GPa.
Two of the composite slabs, marked S-1, will be maintained in the laboratory without loads. From them will be calibrated the variations of the deformations in the prestressed steel tendons and in the concrete matrix, due to prestressing forces and due to the shrinkage of the concrete matrix.
Similarly, for the composite columns, the experimental program consisted of some specific subgroups (two columns per sub-group) of twelve 120x18x18 cm steel-composite precast and prestressed columns (with a specified characteristic material properties of 45 MPa for the concrete matrix, and Esp = 195 GPa for the high-yield steel tendons with nominal diameters of 12,9 mm and 15,3 mm which will be contained in frames made of 5 mm bent mild steel mesh with Es = 200 GPa).
Two of the composite members, marked C-11 with tendon nominal diameter 12,9 mm, and two other marked C-12 with tendon nominal diameter 15,3 mm after their compression by the prestressing efforts will be maintained in the laboratory without long-term loads. By them will be obtained the variations of the strains in the prestressed steel tendons and in the concrete matrix, due to prestressing forces and due to the shrinkage of the concrete matrix.

References

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