# Externally prestressed concrete: anchor block 3D yield design

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## Abstract

In externally prestressed structures, anchors and deviators are used to connect tendons to the main structure. Those reinforced concrete blocks are exposed to large stress concentration and in many cases need 3D non-linear computation to be assessed properly, especially when they are beyond the standard framework. This local stress computation remains a great challenge for externally prestressed bridge design or large span girders design and is often poorly evaluated.

This paper presents the results of a nonlinear 3D analysis of an anchor block belonging to an 80 meters long externally prestressed box girder. This analysis has been done for an actual engineering study (Roissy Charles de Gaulle Airport, Paris) to understand the concrete stress behaviour and cracking causes at the anchorage zone. Each reinforcing bar is modelled, plain concrete is described by the Rankine criterion, and finite elements are 10-nodes tetrahedrons. Then, a yield design computation is performed to assess the safety factor on the ultimate state loading. For the collapse load, an elastoplastic analysis is computed thanks to a static approach and a kinematic approach. This dual approach gives an error estimation in constitutive law. Eventually, stress flaws and rebars constrains are analysed in order to understand the general behaviour of the anchor.

**Keywords:** anchors; yield analysis; reinforced concrete; Rankine criterion; error in constitutive law;

## 1 Introduction

A few months ago, the Strains company was mandated by A.D.P.[1] to study anchor block in externally prestressed box girder in order to find cracking causes. This study is still in progress and our conclusions could evolve in the next months. However, it is a good illustration of how convex optimization can solve reinforced concrete computations and the questions it raises.

More generally, using 3D Finite Elements with non-linear behaviour is still very unusual: convergence difficulties, lack of error estimation and computation cost prevent many engineers to use this to verify structures. Those are major drawbacks which make analytical checks or strut and ties computations much more attractive, even if they are very difficult to apply to complex or nonstandard structures.

Convex Optimization could change this statement. In the last decades, this mathematic framework to solve minimization problems appears to be particularly efficient when it comes to solve mechanics problems resulting in energy minimization. The main difficulty is to fit within the

[1] Aéroport de Paris