論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Numerical and Experimental Evaluation of Dynamic PT Tendon Fracture Mechanics
著者(和文)	GKOLFINOPOULOSIoannis
Author(English)	Ioannis Gkolfinopoulos
出典(和文)	学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第12599号, 授与年月日:2023年9月22日, 学位の種別:課程博士, 審査員:千々和 伸浩,岩波 光保,佐々木 栄一,河野 進,丸山 泰蔵
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第12599号, Conferred date:2023/9/22, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	土木・環境工学 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 学術 ）
学生氏名： Student's Name	Ioannis Gkolfinopoulos	審査員主査： Chief Examiner	千々和伸浩

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis investigates the bonding resistance between steel and concrete within the context of pretensioned concrete structures This vital aspect of structural engineering is a cornerstone of construction, ensuring the integrity and longevity of concrete elements subjected to various loads and environmental conditions.

The bonding resistance, is important for structural stability and can be separated into three essential components: adhesion, friction, and mechanical anchorage. Adhesion and capillary forces develop during concrete curing. However, the effectiveness of adhesion diminishes significantly due to its susceptibility to failure even with minor displacements. On the other hand, friction, a force resulting from the interaction between two surfaces in contact, becomes significant. This frictional force is influenced by multiple factors such as external loads, changes in concrete volume, roughness of the steel surface, and even the composition of the concrete itself. Mechanical anchorage, primarily present in ribbed bars or strands, becomes effective due to the mechanical interlock that between the steel surface and the concrete. This interlock effectively restricts any relative movement, providing a robust anchoring mechanism. The effectiveness of this anchorage hinges on the behavior of the concrete mortar in the bonding joint, particularly its deformation characteristics and shear capacity.

In pre-tensioning, bonding involves two critical parameters: the transfer of prestress along the transmission length and the anchoring of the tendon's tensile force within the flexural bond length. In pre-tensioning, a combination of adhesion, friction, Poisson effect, and wedge action collaborate to establish the bond for tendons, while mechanical interlock becomes the dominant factor for strands.

A deep understanding of bond behavior across both the transmission length and flexural bond length is paramount for the successful anchorage of prestressed tendons in concrete. Although rare, anchorage failure can be attributed to bending cracks occurring too close to the element's end, disrupting the equilibrium between the forces in the tendon and the surrounding concrete. This signifies the importance of accurate design models, such as Eurocode 2, Model Code 2010, ACI 318, AASHTO, and the Japan Road Association guidelines. These guidlines provide engineers with methods to compute crucial parameters like bond stress, transmission length, and flexural bond length.

To investigate the bond behavior as a first step, a series of tensile test were conducted under different strain rates ranging from $0.001s^{-1}$ to $0.5s^{-1}$, and focus on determining the Johnson-Cook model and damage parameters for SBPR 930/1080 Type B No. 1 tendon steel. The primary aim is to facilitate the fracture analysis of post-tensioned concrete members. The calculated JC parameters exhibit robust agreement with the experimental data, thus affirming the precision of the damage model. The validation process extends to utilizing commercial finite element method software, which effectively corroborates the alignment between numerical and experimental tensile data. This approach offers a practical and efficient solution compared to alternative analytical models. Nonetheless, the calibration of model parameters requires an extensive dataset derived from several different experimental cases to ensure optimal accuracy. Although slight disparities between FE simulations and experimental outcomes were identified, the model excels in predicting intricate effects like strain concentration and geometrical deformation.

Afterwards an experimental investigation into bond performance and degradation was performed for this thesis. This phase involves embedding plain smooth bars into both normal and ultra-high strength grouting mortar, testing these configurations under varying conditions including static dynamic pullout rates. Additionally, lateral compression tests conducted at $0.25f_c$-$0.5f_c$, further improve the understanding of bond performance. The purpose of this comprehensive testing regime is to obtain material parameters for the subsequent finite element modeling and to propose an analytical

bond constitutive model. The proposed model is found to closely align with experimental results, a validation reinforced by the model's successful application to concrete material data from other researchers. This promising versatility extends to diverse material strengths, smooth bar diameters, and pullout rates.

Thorough evaluation of stress and strain distribution results for the embedded bar solidifies the model's effectiveness in simulating bond degradation and the impoartance of cross-sectional bar deformation at various pullout stages. This insight extends to understanding the consequential effects on frictional stress and strain distribution. Furthermore, the proposed bond constitutive model presents researchers with a tool capable of simulating the development and degradation of bonds in complex structures. Particularly valuable for brittle materials like concrete and grouting mortar interacting with sturdier counterparts like steel, this model aptly accounts for cohesion, friction, confinement stress, and debonding rates. Its reliance on fundamental material parameters eliminates the need for cumbersome and resource-intensive experimental procedures, thus streamlining the analysis process.

In conclusion, the thesis discuss the importance of bonding resistance in pretensioned concrete structures, investigating its components and their dynamic interaction. It involves both theoretical understanding and practical application through thorough experimentation, numerical modeling, and analytical validation. This holistic approach empowers engineers and researchers to design and construct enduring structures with a profound understanding of the bond between steel and concrete.