Kinematics-Based Modelling of Compact Footings

Auteur : Spada, Giorgia
Promoteur(s) : Mihaylov, Boyan
Faculté : Faculté des Sciences appliquées
Diplôme : Master en ingénieur civil des constructions, à finalité spécialisée en "civil engineering"
Année académique : 2018-2019
URI/URL : http://hdl.handle.net/2268.2/6778

Student: **Giorgia SPADA**

Promoter**: Boyan MIHAYLOV**

University of Liège,
Faculty of Applied Sciences (ArGEnCo)
Master's Degree in Civil Engineering
Academic Year 2018/19 - June 2019

Kinematics-Based Modelling of Compact Footings

The main objectives of this thesis work are the extension and validation of a Two-Parameter Kinematic Theory (2PKT) for shear behavior of deep beams to concrete compact footings. The foundations have the purpose to transfer the load of the superstructure and its weight to the soil layers. Generally, reinforced concrete footings are designed without shear reinforcement; therefore, these elements are susceptible to brittle failure according to the amount of diagonal cracking due to shear stresses. Large-scale tests provided by *Uzel* (2003) are the starting point for the analysis. One-way shear is considered, thus the footings were modelled to represent a strip of the element subjected to point load (simulating the load coming from the column footing) and uniformly distributed loads imposed by a set of hydraulic jacks equally spaced (which reproduce the simplified soil pressure, in practice it is not uniform, but it varies according to the soil type).
Then, Finite Element Models (by using program VecTor2) of tests are performed in order to obtain reliable and accurate predictions and enlarge the footings database, for which, in the literature, few suitable tests are available. Simultaneously, the 2PKT for shear behavior in deep beams was developed for footings, adapting the loading conditions and the shear resistance contributions. By means of the 2PKT it is possible to predict the shear failure load, the crack widths near failure, and the complete deformed shapes (Figure 1 shows a comparison between the real test displacement and the predicted by the 2PKT in blue dots). The two parameters used in the models are the ultimate vertical displacement of Critical Loading Zone (CLZ) and the average tensile strain in the longitudinal reinforcement on the flexural tension side. In order to show the validity of the theory a parametric study is developed by using FEM models (in Figure 2, 3 and 4 it is possible to observe the parametric study for sample AF1 UN100). The parameters included in the study are the concrete strength, the longitudinal reinforcement ratio and the length of the footing. Based on the use of non-linear finite element calculations validated against experimental results, it is possible to validate the 2PKT extended to concrete compact footings. The 2PKT method reproduces well the observations and the measurements during the large-scale laboratory tests. The average experimental-to-predicted strength ratio obtained with the extended 2PKT calculations for the footings database (*Uzel*'s tests) and the FEM models is 1.04 and the Coefficient of Variation (CoV) is 14.2%. The comparison of 2PKT provisions with respect to real laboratory tests and non-linear finite element models is performed in terms of shear failure load, crack widths near failure, and the complete deformed shapes (developing also a MatLab code in order to visually compare the deformation patterns, Figure 1 for sample AF1 UN100 for example). This thesis work is the starting point for the validation of the 2PKT. The FEM models created (an example is shown in Figure 5 and 6 varying *L/d* ratio) for the parametric study could be actually validated by means of real laboratory large-scale tests, in order to experimentally demonstrate the shear predictions of the theory and enlarge its validity.

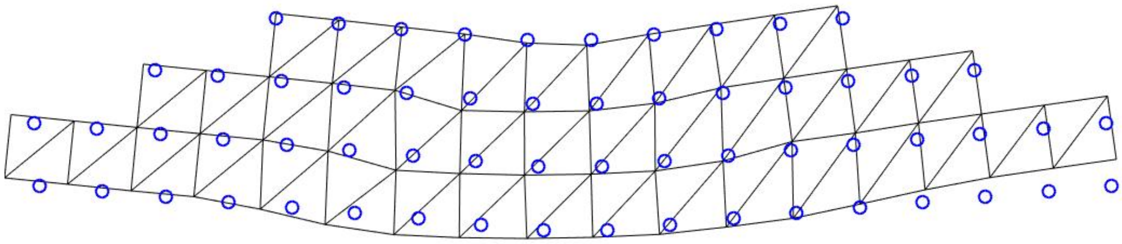


Figure 1: Comparison between actual test displacement and 2PKT predictions (Blue dots) for UN100 (Scale Factor=30)

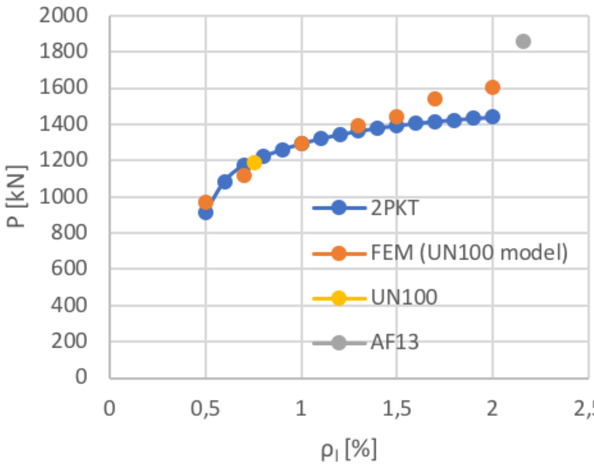


Figure 2: Parametric study varying the longitudinal reinforcement ratio using UN100 as model

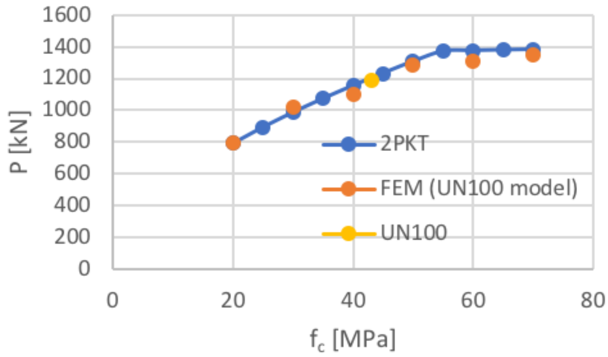


Figure 3: Parametric study varying the concrete strength using UN100 as model

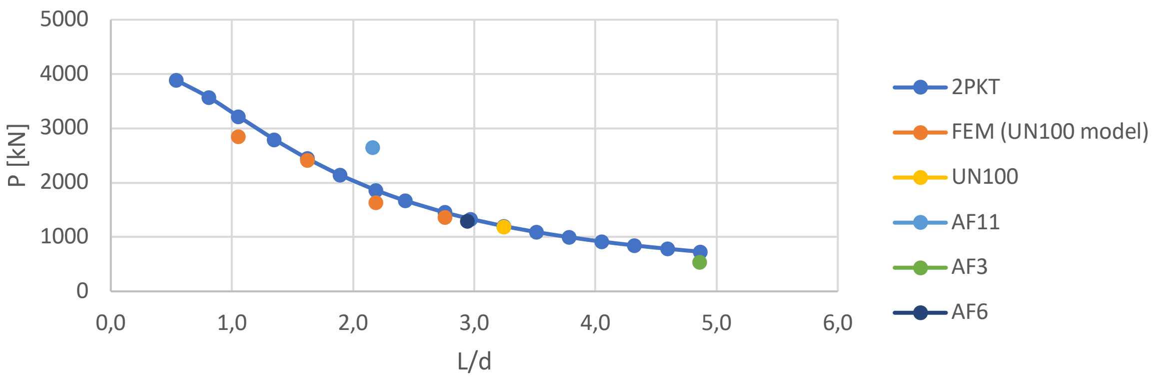
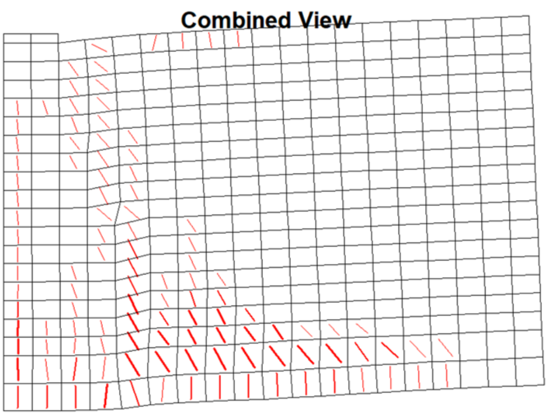


Figure 4: Parametric study varying the L/d ratio using UN100 as model



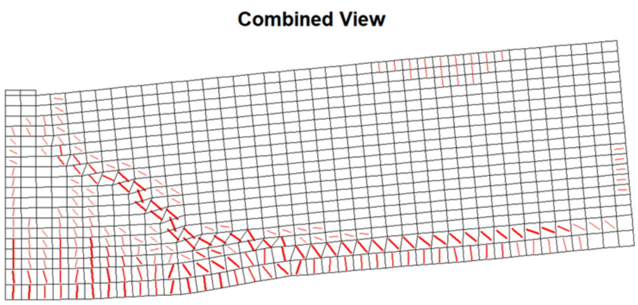


Figure 6: Finite element models (modelled with VecTor2) – Combined view of cracks at failure AF1 UN100 with $\frac{L}{d} = 3$

Figure 5: Finite element models (modelled with VecTor2) – Combined view of cracks at failure AF1 UN100 with $\frac{L}{d} = 1.5$