Numerical modelling of slab-column concrete connections at elevated temperatures

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Abstract

Flat slab-column concrete frames are an economical type of concrete building. The main advantages of this type of frame structure are that they are easy to construct, relatively cheap to build and offer flexible column arrangement. However, they are susceptible to a type of failure known as “punching shear”, where columns “punch” through slabs. This is a particularly dangerous type of failure as it occurs suddenly. Punching shear occurring at high temperatures, such as in fire, is an obvious concern. This condition has been studied experimentally, but to date, there has been a very little numerical investigation of the topic. This paper presents a numerical study of the mechanics of punching shear failure at elevated temperatures, with a focus on the role of load induced thermal strain (LITS), which is shown to explain apparently anomalous experimental results.

Keywords: punching shear, fire, FEM, LITS, load induced thermal strain.

1 Introduction

Flat plate concrete structures are an economical type of building frame commonly used for offices and similar structures. They are easy to construct and are relatively cheap to build. Nevertheless, they are susceptible to a type of failure known as “punching shear” (**Error! Reference source not found.**), where columns punch through floor slabs, leading to collapse. This is a particularly dangerous type of failure as it is brittle and occurs suddenly. Punching shear occurring at high temperatures, such as in fire, is more concerning still [1]. There are very limited studies about punching shear in fire. This paper presents a numerical study of the mechanics of punching shear failure at elevated temperatures, with a focus on the role of load induced thermal strain (LITS), also known as transient thermal strain.

In 2004, a car park collapsed in Gretzenbach, Switzerland due to fire [1], which raised a concern about punching shear design in fire. Therefore, various experimental studies

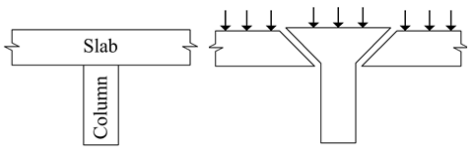

Figure 1. Schematic diagram of a flat plate structure and the punching shear failure mechanism.

Investigated punching shear in heated slabs. These included Salem et al. [2], Annerel et al. [3,4] and Liao et al. [5]. More recently, Smith et al. [6–8] investigated punching behaviour under fire by testing 15 slabs with different heating and support conditions (laterally and rotationally restrained and unrestrained). They noted that the deflections of the slabs when heated were in the opposite direction to that expected – away rather than towards the heat source, as a simple thermo-mechanical analysis would predict (Figure 2).

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