Engineering Structures 87 (2015) 126–138

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Response of precast prestressed concrete hollowcore slabs under fire conditions

A.M. Shakya, V.K.R. Kodur *

Department of Civil and Environmental Engineering, Michigan State University, United States

ARTICLE INFO

Article history:
Received 6 May 2014
Revised 8 January 2015
Accepted 12 January 2015

Keywords:
Precast concrete slabs
Fire performance
Hollowcore slabs
Fire resistance tests
Numerical model

ABSTRACT

This paper presents results from experimental and numerical studies on the behavior of precast prestressed concrete (PC) hollowcore slabs under fire conditions. Six PC hollowcore slabs were tested under simultaneous application of thermal and structural loads. The test variables included type of aggregate in concrete, load level, fire exposure and restraint conditions at the supports. The hollowcore slabs did not experience any fire induced spalling and the failure of all slabs occurred through temperature on unexposed side of slab reaching limiting temperature criteria. Data generated from fire tests show that aggregate type, fire scenario, load level and end support condition have significant effect on the fire performance of PC hollowcore slabs. Further, results from fire tests indicate that typical hollowcore slabs can sustain service loads for at least two hours under standard and design fire conditions. Data generated from fire tests is utilized to validate a numerical model developed for evaluating fire performance of PC hollowcore slabs. Predicted cross-sectional temperatures and deflections of the slab, generated from the numerical model, compare well with measured data from fire tests indicating that the proposed model is capable of tracing the behavior of PC hollowcore slabs under standard and design fire conditions.

1. Introduction

In recent years prestressed concrete (PC) hollowcore slabs are being increasingly used in building applications due to numerous advantages these slabs offer, such as cost-effectiveness, architectural aesthetics, speedy construction, space utilization and low maintenance costs, over other floor systems. Structural fire safety is one of the primary considerations in buildings and hence, building codes specify fire resistance requirements for slabs. At present, fire resistance ratings of slabs is assessed through standard fire tests and prescriptive rules wherein, fire resistance is determined based on slab thickness and concrete cover thickness to reinforcement. These prescriptive rules, developed based on data from standard fire tests, consider only limited parameters and often, do not yield realistic fire resistance.

PC hollowcore slabs generally comprise of concrete and prestressing strands as reinforcement. Flexural capacity of such hollowcore slabs is generally governed by stress level in strands. When subjected to fire conditions, both concrete and prestressing steel experience loss of strength [1], leading to degradation in moment capacity with fire exposure time. When the capacity falls below the moment, due to applied loading, failure of the slab occurs. The rate at which moment capacity of a hollowcore slab degrade, is a function of number of parameters including cover thickness to prestressing strand, core size, fire intensity and support conditions. The effect of many of these critical parameters on fire response of hollowcore slabs is not fully taken into consideration in current prescriptive provisions. In fact in conventional practice, the strength failure of the slab is said to occur when the temperature in the prestressing strand reaches a critical temperature. The failure of hollowcore slabs can also occur when the temperature on the unexposed surface of the slab exceeds the limiting temperature criteria, or flame breaches through the slab.

In the last four decades, several experimental studies have been carried out to evaluate fire resistance of PC hollowcore slabs. The notable fire resistance tests on PC hollowcore slab were performed by Abrams [2], Borgogno [3], Andersen and Lauridsen [4], Schepper and Anderson [5], Acker [6], Lennon [7], Fellinger et al. [8] and Jensen [9], Breccolotti et al. [10], Bailey and Lennon [11], and Aguado et al. [12]. The test parameters included slab thickness, cover thickness to reinforcement, concrete strength and load level. These fire tests mainly focused on obtaining fire resistance ratings for these slabs, and were performed by exposing slabs to standard fire conditions and under service level loading. In most cases, unexposed slab surface temperature or the critical temperature in strand

* Corresponding author. Tel.: +1 517 353 9813.
E-mail addresses: shakyaan@msu.edu (A.M. Shakya), kodur@egr.msu.edu (V.K.R. Kodur).

http://dx.doi.org/10.1016/j.engstruct.2015.01.018
0141-0296/