Ain Shams University
Faculty of Engineering
Structural Engineering

# Behavior of RC Beams with Lap Splices Exposed to Fire

A Thesis submitted in partial fulfillment of the requirements of the degree of

**Doctor of Philosophy in Civil Engineering**

**(Structural Engineering)**

By

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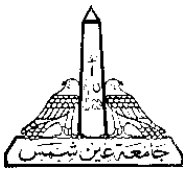
2019



Ain Shams University
Faculty of Engineering
Department of Structural Engineering

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Thesis Title : **Behavior of RC Beams with Lap Splices Exposed to Fire**
Degree : **Doctor of Philosophy in Civil Engineering (Structural)**

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# DECLARATION

This dissertation is submitted to Ain-Shams University for the degree of Doctor of Philosophy in Civil Engineering (Structural Engineering). This work included in this thesis was carried out by the author on the department of Structural Engineering, Faculty of Engineering, Ain-Shams University, Cairo, Egypt. No part of this thesis has been submitted for a degree or qualification at any other university or institution.

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# ABSTRACT

Due to the limitation of the length of the reinforcing bars, lap splices are commonly used in reinforced concrete (RC) structures. Steel bars must be connected in field to provide continuity of reinforcement according to design requirements. Many ways that used in field to produce continuity of steel bar; welding, using mechanical connectors or by providing sufficient lap splices. Consequently, lap-splices are commonly used in reinforced concrete (RC) structures to solve such problem. Fire is considered one of the serious causes of damage and cause collapse of reinforced concrete structures. Many collapse cases took place in recent years due to fire all over the world. The effect of fire on structural safety is dependent on fire temperature, duration and firefighting technique. Yet, fire effect has received little attention from researchers, especially the effect of fire on splices. Thus, this study aims to shed light on study the effect of fire on the behavior of RC beams with tension lap splices and also to evaluate the reduction in concrete bond strength during fire. For this purpose, an experimental program and theoretical analysis of thirteen RC beams, with lap-splice, have been tested. All beams are of a 150X300mm cross-section and 3000 mm span length. As Egyptian Code recommends, 600mm length of lap-splice have been used. The experimental program includes different variables such as: Thickness of concrete cover (20mm & 30mm), temperature (650°C & 800°C) and duration of fire exposure (1hr, 2hrs & 3hrs). Experimental program extended also to study heat distribution inside by measuring temperature at 5 point Distributed at mid-section of spliced zone. Load - deflection relationship and crack propagation are recorded during loading from which we can judge the effect of each parameter on the ductility and mode of failure of each beam. Results showed that the fire exposure significantly affect the lap-splice of RC beams mode of failure. As Splitting failure was observed instead of flexural failure. Furthermore, ultimate load and deflection were found to decrease when the fire time duration increase. Also, is was observed that the fire has a major effect on the bond strength of lap-spliced RC beams and ductility has different behavior when compared with non-fired beam. Consequently, codes have to take fire effects on the lap-splice in design process. Finally, theoretical results agree very well with the experimental results.

**Keywords:** Lap-spliced, bond strength, fire duration, RC beam, failure behavior, Ductility.

# TABLE OF CONTENTS

# List of Figures