

学校编码: 10384 分类号密级
学号: 25320141151784UDC ____

厦 门 大 学

硕 士 学 位 论 文

火灾作用下预应力连续梁桥力学性能分析

Mechanical Performance Analysis of Prestressed Continuous
Beam Bridge Under Fire

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专业名称: 桥梁与隧道工程

论文提交日期: 2017年04月

论文答辩时间: 2017年05月

学位授予时间: 2017年月

答辩委员会主席:

评 阅 人:

2017年06月

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摘要

随着经济的发展,我国桥梁等基础设施得到了飞速发展,但随之而来的就是各种安全隐患,火灾就是其中一种安全隐患。一旦发生火灾,轻则中断交通、损害生命和财产利益,重则导致桥梁直接崩塌,难以修复。但我国对于桥梁受火的研究却还是刚刚起步,研究水平远远落后于实际工程需求。因此加快桥梁受火的研究显得十分必要。

本文以厦门市大嶝桥为研究对象,主要的研究内容如下:

①根据现有的研究成果,归纳火灾高温状况下,混凝土、预应力钢筋力学性能参数以及热工性能参数,揭示出混凝土热传导系数、弹性模量、热膨胀系数、预应力钢筋屈服强度、极限屈服强度、比热、容重等参数随着温度的改变情况。

②基根据热力学知识,确定有限元求解温度场、应力场的方法和流程;采用加权余量法中的 Galerkin 法推导瞬态热传导微分方程;把结构受火的时间域分成不同的时间单元,通过 Crank-Nicolson 有限差分进行时间域上的有限差分。

③结合连续箱梁桥大嶝桥的工程背景,参考桥梁火灾的现场资料和成果,确定模型的边界条件、分析选取混凝土、预应力筋的本构模型,建立了大嶝桥的有限元模型。

④在模型的基础上,分别模拟研究了桥面受火、桥下受火以及桥内受火三类不同的受火情况,并将其细分为十种不同的受火工况,分析了各受火工况下桥梁受火跨各关键点的温度时程、底板挠度时程、不同截面的应力随时间变化情况,以及底板预应力钢筋的应力时程曲线。

⑤结合大嶝桥实际受火情况,分析了受火底板不同深度的温度变化,并分别比较在自重作用下以及车道荷载作用下火灾前和火灾时桥梁的力学性能变化,研究火灾对桥梁中混凝土、预应力筋等材料的影响,另外还分析了火灾对桥梁正常使用极限状态影响。

关键词: 火灾, 温度场, 应力场, 力学性能

Abstract

The development of China's bridge and other infrastructure is speeding up dramatically with the development of economy. However, a variety of security risks such as conflagration are coming along. When a bridge catches the fire, not only can the fire cause the traffic jam and death, but also it can bring many disasters to the bridge. For example, the collapse or even the permanent loss of it will follow. Therefore, it is urgent for us to solve these problems. However, the research of bridge under the fire in our country is only in its infancy. Further more, the level of it falls far behind the actual needs of engineering. In a word, to accelerate the study of bridge under the fire is of a great necessity.

This paper takes Dadeng Bridge in Xiamen as a research object, and the main contents are as follows:

① Based on the experimental study of domestic and foreign scholars, the paper sums up the relationship between the mechanical properties and thermal parameters of concrete and prestressed steel after high temperature fire. Such as the concrete heat conduction coefficient, elastic modulus, thermal expansion coefficient and the relation equation of temperature; the relationship between prestressed reinforcement yield strength, ultimate strength, thermal conductivity, specific heat and density with temperature change.

② Based on the thermodynamics, the method and process of finite element method for solving temperature field and stress field are established; The transient heat conduction differential equation is derived by the Galerkin method; The time domain of the structure is divided into different time units, and the finite difference method (Crank-Nicolson) is used to make the difference.

③ The combination of continuous box girder bridge Dadeng bridge engineering background, reference bridge fire field data and results, to determine the boundary conditions of the model, analysis and selection of concrete, prestressed reinforcement constitutive model, build finite element model of Dadeng bridge.

④ On the basis of the model, respectively studied three different types of fire, including deck fire, fire under the bridge and fire in the bridge. Then dividing them into ten different fire conditions, analysis the temperature range of key points, the floor the

deflection time history, different sections of the stress changes and stress time history curves of prestressed reinforced floor.

⑤Considering the actual fire with Dadeng bridge, the analysis of the temperature changes by the fire floor at different depth, and compared the changes in mechanical properties under the action of gravity and lane loading. Also, the effect of fire on the material was studied, including concrete, prestressed reinforcement and so on. In addition, the influence of serviceability limit state of bridge on fire is analyzed.

Key words: fire, temperature field, stress field, mechanical properties

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