Engineering Structures 105 (2015) 264–276

Contents lists available at ScienceDirect

Engineering Structures

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

A weathering steel elastomer joint for the connection between new and existing bridges

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ARTICLE INFO

Article history:
Received 24 December 2014
Revised 21 September 2015
Accepted 8 October 2015

Keywords:
Bridge joint
Elastomer
Weathering steel
Bonding
Corrosion
Aging
Tensile test
Cohesion
Adhesion

ABSTRACT

Mechanical behavior and durability of a new bridge Weathering Steel Elastomer Joint (WSEJ) is investigated. The strength and deformation performances of the joint are determined through an experimental campaign, in order to verify if this element might comply with design requirements. A number of 30 specimens is considered, comprising samples with three different types of steel components, namely weathering (Cor-Ten), stainless (Inox) and carbon (S355) steel, two different shape types of the connecting rubber and two types of specimen geometry. Neutral Salt Spray and Cyclic Corrosion tests, simulating the environmental effects on steel component, are performed to control the joint capacity of maintaining resistance characteristics during its lifecycle. Moreover, temperature tests are carried out to simulate aging of rubber. Intact, corroded or aged specimens are all subjected to tensile tests to determine their strength and corresponding deformation capacity. Comparisons of test results are performed between groups of specimens differing only for one characteristic (deterioration state, corrosion test performed, rubber shape and geometry).

1. Introduction

Expansion joints in bridges are structural elements used to bear deformations caused by traffic loads [1], temperature variations and ground movements in order to prevent damage in other parts of the structure like girders, slabs or abutments [2]. These elements are usually placed crosswise to the bridge longitudinal development. A rubber component is typically used for sealing functions in order to protect the other bridge components from damage deriving from water, salt and other roadway contaminants associated with deck runoff.

The joint under investigation was specially designed to connect two decks – one of an existing old bridge and the other of a new ductile bridge – that are segments of an Italian highway. The use of the joint is necessary due to the stiffnesses of the two bridges, which are different, because the bridges were designed under different codes in periods separated by many years. The bridge behavior under seismic actions is related to the configuration of the piers [3], which is determined by the pier shape and quantity and arrangement of reinforcement. These characteristics obviously depend on the code used at the time of the bridge design [4].

The joint considered in this study is produced by a multinational industry (ILPEA Spa) and is made of weathering steel and vulcanized elastomeric rubber. A first peculiarity of the joint is the use of weathering steel, a material not typically employed for this function. Another peculiarity is that the elastomeric component has not only waterproofing or weatherproofing functions, designed to protect the mechanical parts, but it must also have the capability to bear the deformations caused by traffic loading.

Since the joint in question is an innovative invention, it is worthwhile conducting a study that could verify if the joint really has the required resistance characteristics. Furthermore, it is important to control the possibility of maintaining these characteristics throughout the joint's entire life cycle.

Although an in-depth literature review has been conducted, nothing similar to the study presented herein has been found in the literature. There has been some research on the behavior of sealants, including pull-to-fail tension, salt water immersion, aging and on-field tests [5–7] aimed at evaluating and controlling the performances of both solid and foam silicone sealants for small movement expansion joints. Among researches [5–7] only report [7] describes results of laboratory tests on bridge joints made with steel substrates, but no one contemplate the use of weathering steel substrates. Other research [8] focuses on the performance of

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http://dx.doi.org/10.1016/j.engstruct.2015.10.011
0141-0296/

modular bridge joints, composed of rubber and steel, under traffic actions, through high cycle fatigue tests. There is also a general study [9] investigating which joint solutions are more suitable in different applications in American highway bridges, but nothing related to an elastomeric solid component vulcanized onto mechanical elements made of weathering steel.

This paper recounts the motivations that drove the experimental investigation on WSEJ and the kind of tests adopted both for the mechanical characterization of the joint and for the control of the maintenance of resistance characteristics over time. The test results and a discussion about them are also presented.

2. Experimental study and methodology

2.1. WSEJ characteristics

An overview of the WSEJ is presented in Fig. 1, where the constituent materials and the principal dimensions are displayed. The used elastomer was Styrene Butadiene Rubber, whose characteristics are: shore A, durometer hardness 70 and estimated shear modulus $G = 1.2$ MPa.

Vertical sections of the left and right portions of the elastomeric joint are shown in Fig. 2.

The bonding between steel and rubber is obtained by sandblasting and coating the steel surface with a thin layer of primer, which in turn is coated with a thin layer of mastic. The rubber is then superimposed on the mastic and, finally, rubber and steel are bonded together by means of a vulcanization process.

Good adhesion is very important in all rubber composite devices for the correct functioning of materials bonded to the elastomer [10–13]. Moreover it is important, because the theoretical calculus of rubber composite devices is based on the hypothesis of perfect bonding between the elastomer and the other materials [14].

2.2. Motivations

This study was prompted by the producer of the subject WSEJ (Fig. 1), who left joints in an outdoor storage area for some months

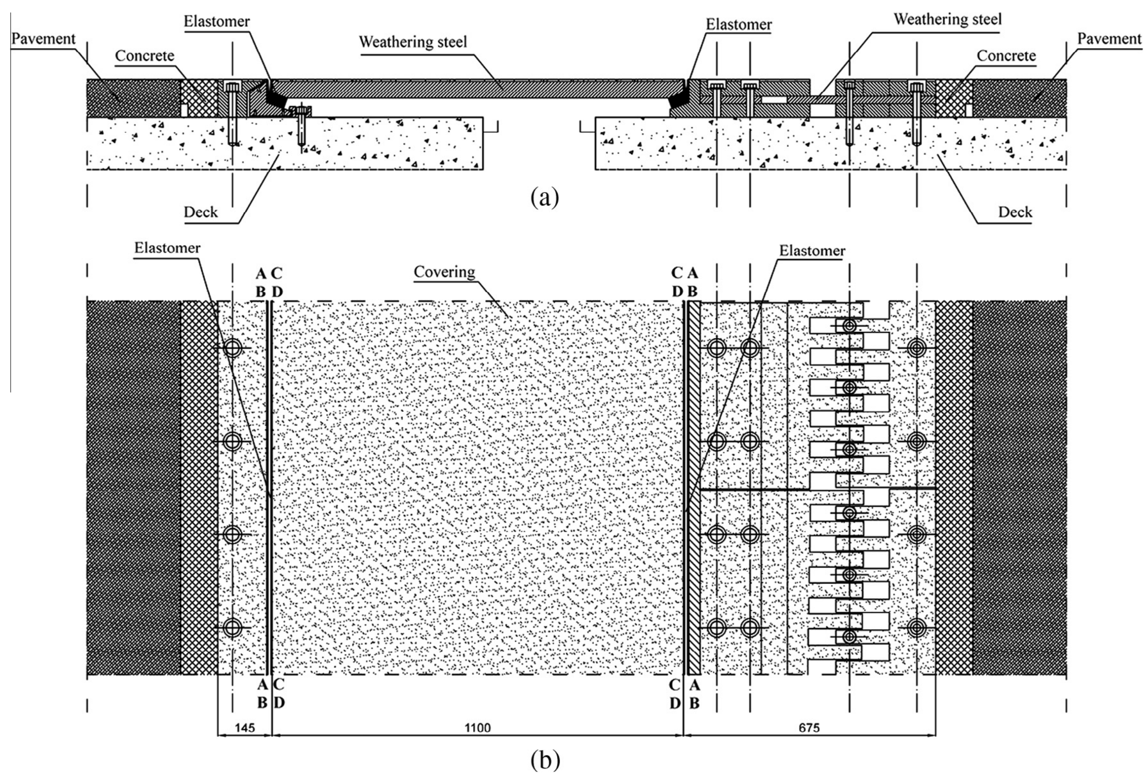

Fig. 1. (a) WSEJ's section and (b) planimetric view of a joint portion. Dimensions in mm.

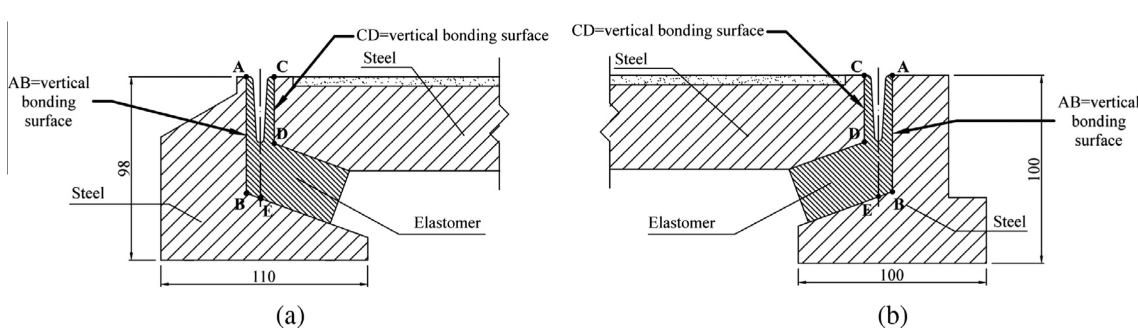

Fig. 2. The “old design” left (a) and right (b) ends of the joint. Dimensions in mm.