Shear Strength Investigation of Concrete Girders with Proposed Horizontal Shear Reinforcements in Webs

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Summary

The horizontal web reinforcement arranged along the depth of the web was proposed as integrated shear reinforcement with stirrups. According the plane-section assumption, the shear strength provided by compression stresses in the concrete at ultimate stage can be calculated. A series of model girders with horizontal reinforcement in webs were fabricated and tested. The tests show that the horizontal web reinforcements can not only carry the horizontal component of the diagonal-tension stress, but also delay the occurrence of diagonal cracking, and reduce the width of diagonal cracks, and increase the rigidity and shear strength of beams effectively.

Keywords: horizontal web reinforcement, shear strength, plane-section assumption, test

1. Introduction

Concrete bridges have apparently predominated in the existing bridges. Statistics show that up to 1989, 70% bridges in Europe, 72% bridges in U.S.A, and more than 90% bridges in China are concrete bridges [1]. However, since 1970s it has been found that quite a few of concrete bridges has diagonal cracks in the web under either construction stage or service stage, and some even worse. The problem lies in many factors, including construction quality, environment influence, and importantly the imperfect shear strength theory in bridge design. The main reason for large crack width in the web is that the shear reinforcement has not provided enough.

MÖrsch predicted that most of the shear stress transfersd from flexural cracks, while only 30% of that was resisted by the uncracked concrete compression zone. In 1960, Kani, et al, conducted a series experiment and was surprised to discover that merely 25% shear stress was resisted by concrete compression zone when beam was loaded to nearly failure, while the rest shear stress was resisted by "mechanical interlocking force" called by Fenwick and Paulay, and dowel resistance of flexural reinforcement [2]. Meanwhile, some scholars now think that the comprehensive effect of mechanical interlocking force and dowel resistance has played more important role in shear strength in small-span flexural structures, but has few influences on the long span structures, especially on the bridge structures under repeated loading. This is one of the main reasons why there are great differences in the different design codes.

In order to satisfy the requirement of shear resistance capacity in design, the various equations and detailing requirement are adopted in the code according to each country's researches and views. Since the early 20th century, a large number of test researches have been carried, and thousands of academic papers have been published to explain the structure behavior under action of combined bending and shear. However, the theory and calculation method about shear strength are immature. The imperfect shear capacity theory in bridge design causes the diagonal cracking in the web during the service stage.

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