Glass Fibre Reinforcement in Bridge Barrier Walls

Ben JUETTE
Product Manager ComBAR
Schöck Bauteile GmbH
Baden-Baden, Germany
Benjamin.juette@schoeck.de

Ben Juette, born 1969, had been working at several engineering offices an construction companies in the United States and in Germany before becoming Product Manager of the glass fiber reinforcement at Schöck. His fields of expertise are structural engineering and GFRP.

Khaled SENNAH
Professor
Ryerson University
Toronto, Canada
ksennah@ryerson.ca

Khaled Sennah is a professor at and chair of the Civil Engineering Department, Ryerson University. He has 25 years of research, teaching and industrial experience. His core area of expertise includes design, evaluation, retrofit and rehabilitation of bridge infrastructure.

Summary

A first world-wide vehicle crash test was conducted on a newly developed GFRP-reinforced PL- 3 bridge barrier system, incorporating bars with ribbed surface and headed ends. Results from tests qualified such innovative barrier system to resist vehicle impact per MASH crash test requirement. Crash test results showed that the developed barrier contained and redirected the vehicle. The vehicle did not penetrate or override the parapet. No detached elements, fragments, or other debris from the barrier were present to penetrate or show potential for penetrating the occupant compartment, or to present undue hazard to others in the area. No occupant compartment deformation occurred. The test vehicle remained upright during and after the collision event. The recorded crack pattern after crash testing shows signs of punching shear cracks, in contrast to the specified vertical flexural crack at the back face of the barrier wall and the two diagonal cracks at the front face of the barrier that form the basis for the AASHTOLRFD design yield-line failure equations.

Keywords: high strength glass fibre reinforcement, crash test, tractor trailer PL-3, TL-5.

1. Introduction

Historically, glass fiber reinforcing bars were developed for installation as crack reinforcement in the concrete decks of bridges in North America, where the intense use of de-icing salts had lead to severe degradation of steel reinforced bridge decks. Whereas the stress levels within these bars are comparatively low (large number of closely spaced small diameter bars), more recently developed glass fiber reinforcing bars have been conceptualized to sustain high stresses over long periods of time. The long-term design value of the tensile strength is similar to that of conventional steel reinforcement. However, these bars behave in a linearly elastic manner up to failure at stresses levels well above 1000 MPa. They can, therefore, sustain substantial accidental loads due to vehicular impacts or earthquakes.

A recent research project studied the behavior of high strength glass fiber bars produced in Europe in concrete bridge barrier walls as they are commonly built in the United States and in Canada. This project culminated in a full-scale crash test on a TL-5 (highest load level barrier wall according to the AASHTO Manual for Assessing Safety Hardware (MASH)) using a 36 ton tractor trailer hitting the wall at a speed of 80 km/h.

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2. Barrier construction

Figure 1: Finished barrier wall prior to testing

A 40-m long PL-3 barrier wall was constructed at Texas Transportation Institute (TTI) as shown in Figures 1.

3. Test results

The barrier sustained cosmetic damage only in the form of tire marks and gouges into the concrete as shown in Fig. 2. Minor cracks in the front and back side of the barrier were observed. The barrier was first hit by the tractor. Subsequently it was hit a second time by the rear end of trailer at a similar point. The second impact caused a punching shear crack. There were no signs of vertical flexural cracks at back face of the barrier wall at the point of impact, as they would be expected based on the yield line failure pattern specified in AASHTO-LRFD Specifications. A horizontal crack had formed at the front face of the barrier wall extending from the point of impact downstream to the following control joint at mid-height of the barrier wall.

Figure 2: Wall and tractor trailer after the test