Laser- and laser-hybrid welding of steel bridge structures

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Abstract

The Norwegian Public Road Administration has been challenged to reduce both cost and environmental impact in the development of bridge concepts for crossing the Norwegian fjords along the coastal highway route E39. Motivated by the experience from shipbuilding and automotive industry, a technology qualification programme has been initiated to enable the use of automated laser- and laser-hybrid welding in production of steel bridge structures. Laser- and laser-hybrid welding is less energy intensive compared with traditional arc welding methods, give less distortion, and reduces the need for heat straightening. High power lasers are very effective in welding of steel plates due to the keyhole mode. High power intensity generates a vapour filled cavity and high penetration depth, enabling improved productivity by using single-pass welding of thick steel plates (> 10 mm) without the need to turn sections. The technology qualification programme consists of welding experiments both on laboratory scale and using an industrial production line. Narrow and deep weld geometry can result in high hardness and weld defects. However, the present work demonstrates that by using a steel quality with low carbon content hardness values well below the requirements can be achieved. This paper presents results and experience from qualification of welding procedures, non-destructive examination and destructive testing, and production of steel sandwich elements. Fatigue tests of laser-hybrid welded butt joints and T-joints are currently being carried out to define appropriate detail categories in accordance with NS-EN 1993-1-9.

Keywords: welding, steel bridge structures, technology qualification.

1 Introduction

The Norwegian Public Roads Administration (NPRA) has initiated one of the most ambitious and ground-breaking large-scaled infrastructure programs whose ambition is to connect the cities Kristiansand and Trondheim without ferry crossings along the coastal highway route E39. Several bridge concepts have been investigated during the last years to enable the establishment of fixed crossings for the wide and deep Norwegian fjords. Among these are long-span suspension bridge, submerged floating tunnel and floating bridges.

In the work of developing large fjord-crossing bridge concepts, the NPRA has been challenged to search for cost-reducing possibilities. Typically, cost reduction for a bridge structure can be obtained be developing optimal design given the traffic and environmental loads the bridge needs to carry. For large steel bridge structures, it was also seen that there is a significant potential for cost-saving by introducing and further development of modern manufacturing methods.

It is now 30 years since the first attempt to combine conventional arc welding with laser beam in a hybrid process [1], laser-arc hybrid welding (LAHW). However, it is only during the last decade