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Welding under service conditions - Influence of the load conditions on the integrity of high strength steel welds

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ABSTRACT

It can be expected, that due to increasing traffic loads many steel constructions like bridges offshore constructions which have been built in the seventies and eighties of the last century will show serious signs of beginning damages. So a large amount of costs and repair efforts will be required to enhance the lifetime of such constructions. An important problem which has to be considered is, that probably many repairs activities must be done under real service conditions of the buildings. This is either due to the importance of the buildings, which cannot be shut down for the duration of the repairs or due to unfavourable weather conditions, e.g. strong winds. Both effects will lead to hardly controllable motions of the weld gaps during repair welds on such buildings. Reliable knowledge about the weld gap motion amplitudes and frequencies and the susceptibility for heat cracking or on the other hand the load capacity and reliability of such welds is strongly required.

INTRODUCTION

Steel constructions are exposed to increasing loads which are induced by rising traffic, stronger wind conditions ore extended operating times in combination with higher loads. Therefore damages are generated more and more and it can be expected that the efforts for repairs will be increase strongly in the next decades. The problem is that repair works not necessarily will be enabled under optimized conditions and that is to say that for such works constructions like steel bridges or offshore platforms cannot be shut down temporarily. This is either to the importance of many buildings with regard to a non-disturbed traffic or to the circumstance that under rough environmental conditions loads perhaps produced by strong winds cannot be avoided completely. Therefore it has to be taken into account, that during repair works on operating constructions relative movements of the weld gaps can be occur which affect the strength and the quality of welds produced under service conditions. The question which must be answered is which quality of a weld generated under service conditions and which boundary conditions must be followed in order to guarantee a reliable quality and strength of such welds in steels.

BACKGROUND

The structure of the weld can be affected principally in two different ways by strain amplitudes during the welding process. In a crack free weld the grain structure after solidification may be affected by alternating strains. In [Schiebel] the influence of strain amplitudes during welding on the residual stresses and the toughness of the welds of a structural steel with a yield strength of 460 N/mm² was investigated. A general correlation between the strain amplitude and frequency and an embrittlement of the welds or the magnitude of residual stresses could not be found. However the grain size as a consequence of the load conditions was not observed. The dominating failure which may occur due to welding under service conditions is the occurance of hot cracking in the weld zone. Hot cracks can be generated in the heat affected zone (HAZ) adjacent to the weld seam as reheating cracks, when strains in longitudinal direction are present in combination with thin films of phases with a low liquation temperature. Due to the stronger grade of restraint in longitudinal direction elastic strains are formed but the related forces cannot be transmitted by liquid films. The consequence is the generation of cracks in the transition zone from the weld seam to the HAZ so called liquation cracks. The probability of the occurrance of liquation cracks does not depend primarily on the presence of additional loads. It is more a consequence of the hot cracking susceptibility of the material and the shrinkage conditions. Another important crack generation mechanism is solidification cracking which occurs directly in the weld seam during cooling down of the weld. This mechanism leads to hot cracking in the transition stadium from the liquid the solid state. The cracks normally occur along weld metal grain boundaries and particularly in the weld centre. This mechanism is facilitated by the generation of a dendritic grain structure. Very important factors affecting the solidification crack susceptibility are the presence of low melting phases at the grain boundaries like sulphur-iron compounds in steel, the solidification range of the metal, the cooling curve and the magnitude of the strains occurring due to shrinkage tendency or on the other hand additional applied loads. Unfortunate combinations of the solidifi-

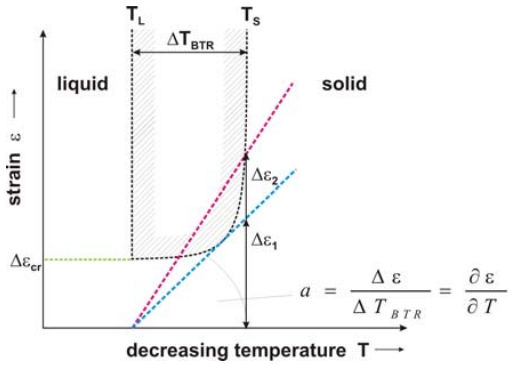

Figure 1: Principle of ductility curve and brittle temperature range (BTR). Interaction between strain rate and hot crack susceptibility. [Prokhorov, Senda].