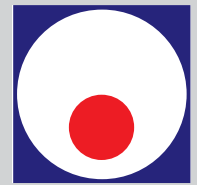




FACULTY OF MECHANICAL AND CIVIL ENGINEERING  
IN KRALJEVO  
UNIVERSITY OF KRAGUJEVAC



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# Dependence of Mechanical Properties of the Base Metal and Welded Joint of the High Strength Steel S690QL on Elevated Temperatures

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*In this paper is analysed behaviour of mechanical properties of the welded joint and base material of high strength steel S690QL at elevated temperatures. The exposure to elevated temperatures could lead to deterioration of mechanical properties of steel as well as to decreasing of load bearing capacity. Since this steel belongs to a group of steels with exquisite mechanical properties, the aim of this work is to show which is the critical temperature when its mechanical properties are going to worsen. For that purpose, an experimental investigation has been carried out. The specimens were taken both from the welded plate and the base material. The welding was performed with GMAW procedure using two types of filler metals with different mechanical properties for root layer and cover ones. The experiment was performed within the temperature range 20°C to 550°C. The obtained results show the difference with respect to several references, including the European standards, steel producers recommendations and some other researches results. Therefore, studying of mechanical properties of this steel at elevated temperatures is of the utmost importance.*

**Keywords:** High strength steel, S690QL, Welded joint, High temperature, Mechanical properties.

## 1. INTRODUCTION

With constant advancements in the field of welding technology, there is a growing need for high strength construction steels such as the steel grade S690QL which is analysed in this paper. In order to maintain good weldability, the carbon content in high strength steels has to be as low as possible (max 0.22%) and the steel should have good mechanical properties which would make the welded construction reliable and light. When complex welded constructions are made, especially the ones made of steels of wide cross-sections, the steel is often heated (preheated, additionally heated and tempered), and the process engineers and designers often find themselves in a dilemma concerning the maximum temperatures allowed for this process. In the literature, wide ranges of these temperatures can be found, depending on the thickness of the welded plates i.e., their thickness equivalents. The aim of this experimental paper is to determine the maximum working temperatures at which both base metal (BM) and weld metal (WM) keep their high strength values.

Dependence of mechanical properties of the base material and welded joints on the temperature has been subject of numerous investigations [1-6]. Due to that, we want to give our contribution to understanding of influence of high temperatures on mechanical properties.

The results shown in the papers [1-4, 6-8] represent a good starting point to understanding the influence of temperature on the base material mechanical properties. However, this influence has not been analysed particularly for the welded joints of high strength steels, which are very sensitive not only to local input of heat that occurs during the welding process but also to elevated working temperatures. Due to these reasons we have chosen to perform complex experimental investigations both of the base material and the welded joints. Some of our published papers [9, 10, 11] studied the high steel grade S690QL and certain zones of welded joints from the aspect of mechanic and metallurgical properties. In these papers different

welding methods and different filler materials were used in order to find the most suitable welding technology. In the present paper we have chosen the MAG welding method and two different filler materials. The root passage was done using austenitic filler material, and the passes were filled with the filler material of the strength similar to the base material strength. Thus, good ductility of the joint and the minimum stress concentration are achieved, while residual stresses in the welded joints are significantly decreased.

## 2. SELECTION OF THE MOST SUITABLE WELDING TECHNOLOGY

### 1.1. Base metal

Since behaviour of the steel S690QL is studied at elevated temperatures, the welded joints have to be welded using the most suitable welding technology. The steel S690QL is produced under special conditions by heating up to the austenite region, rolling and finally by controlled cooling. The steel produced in such a thermo-mechanical treatment process (Quenching + Tempering – Q + T steel) is highly resistant and has good toughness which is maintained even at low temperatures [12]. There are three modifications of this steel that differ only in the guaranteed impact toughness. In fact, all the modifications have the same guaranteed impact toughness of 27 J but different transient temperatures. For the steel grade S690QL it is 47 J at -40°C. The chemical composition and the most important mechanical properties of the steel S690QL are given in Tables 1 and 2 [9, 10, 11, 16].

### 1.2. Selection of the welding technology

The MAG/MAG method was proposed for welding of the steel grade S690QL the proposed method is MAG/MAG (GMAW/GMAW), and two different filler materials [11, 12] for the root pass and the cover welds were chosen (Tab. 3).

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