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TRENDS IN THE IMPROVEMENT OF LATTICE GIRDERS PRODUCTION TECHNOLOGY IN STEELWORK ZENICA

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ABSTRACT
Lattice girder segments are composed of low alloy steel used for concrete reinforcement and intended for special applications where bending and welding are of importance. Lattice girders are essentially determined by the mechanical properties and the lattice girder geometry.
This article is concerned with trends and practical application of the lattice girder production technology. After hot rolling, the wire undergoes a further processing in the cold state. Compared to the hot-rolled steel, the new cold-formed wire has a lower ratio between tensile strength and yield stress and a lower elongation at maximum load. Ageing of steel also increases yield stress and tensile strength and reduces ductility. To make sure that lattice girders provide all required properties the cold rolled wire has to be produced with a certain degree of over-quality in ductility properties.
Keywords: Lattice girders, Multi-phase technology, Cold rolling, Over-ductility

1. INTRODUCTION
Lattice girder (e.g. SP type 5) is a three-dimensional metallic structure comprising an upper chord, two lower chords and continuous diagonals (zig-zag) which are welded to the chords, as it shown in figure 1.
Because of using this final product for reinforcement it is essentially important to save ductile properties after cold deformation and welding. in achieving this goal, it was necessary to improve the production technology in every phase: in steelplant improving purity of steel, in wire rod mill – dimension control, in cold drawing phase – achieving over ductility, and welding parameters to save wire properties.
At points of intersection, longitudinal and zig-zag rebars are factory electrical resistance welded together by automatic machines. Welding local provides a heat treatment of steel. The main problem is to ensure that the high level of ductile properties is not significantly decreased. The resulting reduction of the deformability depends on the welding amperage, on the time of heating and on the chemical composition of steel (mainly content of C, N, P and S). The carbon equivalent value C_{eq} should not exceed value of 0,12% by mass.
The carbon equivalent value C_{eq} is calculated using the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}, \% \qquad \text{... (1)}$$

where the symbols of the chemical elements indicate their content in % by mass.
The semi-finished material for cold drawn wire dia. 7 mm is usually non-alloy steel hot rolled wire dia. 8 mm with carbon (C) content lower than 0,1% and manganese (Mn) content lower than 0,5%. After hot rolling, the wire undergoes a further processing in the cold state which changes its quality

(e.g. from C4D to B500A according to to EN10080). Compared to the hot-rolled steel, the new cold-formed wire has a lower ratio between tensile strength and yield stress and a lower elongation at maximum load.

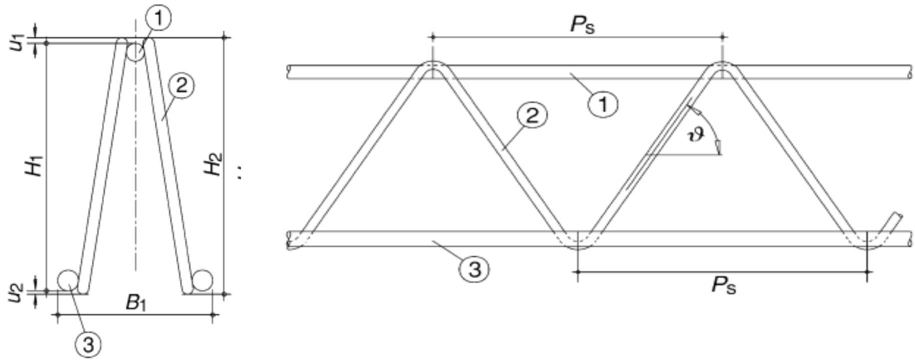

Figure 1. Lattice girder SP type 5 segments: 1 – upper chord (dia. 7 mm) , 2 – diagonal (dia. 5 mm) , 3 – lower chord (dia. 7 mm), height (H_1=125 mm, H_2=135 mm), width (B_1=100 mm), overhang (u_1=5 mm, u_2=5 mm) and pitch of diagonals (Ps=200 mm).[1]

2. RESEARCH RESULTS

The properties of cold drown wire with diameter 7 mm quality B500A produced from hot rolled wire with diameter 8 mm (quality S235JR according to EN10080) using standard technology (C_{eq}=0,15% and average diameter reduction of 23%) are given in Table 1.

Table 1. Properties of cold drawn wire with diameter 7 mm produced using standard technology.

Number of sample	Diameter reduction, %	$R_{p0,2}$, N/mm²	R_{m}, N/mm²	$R_m/R_{e,act}$	A_{gt}, %
ST - 1	23,3	547	587	1,07	3,8
ST - 2	23,1	548	582	1,06	3,5
ST - 3	22,3	531	567	1,07	3,5
ST - 4	22,6	540	581	1,08	3,2
ST - 5	23,1	541	579	1,07	3,2
ST - 6	22,8	537	574	1,07	3,5
ST - 7	23,3	538	570	1,06	3,5
ST - 8	22,6	555	590	1,06	3,3
ST - 9	23,6	563	602	1,07	3,1
ST - 10	22,8	548	582	1,06	3,4
ST - 11	23,6	569	606	1,06	3,5
ST - 12	21,8	480	598	1,24	3,7
ST - 13	23,3	557	597	1,07	3,2
ST - 14	22,8	559	594	1,06	3,3
ST - 15	22,6	557	594	1,07	3,4
ST - 16	23,3	567	602	1,06	3,3

Data given in Table 2. present results of testing the mechanical properties of upper chord and two lower chords of lattice girder type 5. Percentage total elongation at maximum force and tensile strength/yield strength ratio were fallen bellow the characteristic and minimal values (according to EN10080) after welding cold drawn wires to form lattice girders.

Table 2. Mechanical properties of upper chord and two lower chords lattice girder type 5 after welding drawn wire Φ7 mm produced using standard technology 5.[2]

Testing results	$R_{p0,2}$, N/mm²	$R_m/R_{p0,2}$	A_{gt}, %
Minimum value x_{min}	569	1,02	1,0
Average value of test results X	588	1,03	2,3
Maximum value x_{max}	604	1,04	3,8
Characteristic and minimal values according to EN 10080:2005	475	1,03	2,0
Characteristic and average values according to EN 10080:2005	510	1,05	2,5

Regardless the semi finished drown wire had had acceptable ductile properties, after welding to form lattice girders, these properties would be deranged. Properties of the lattice girders are significantly affected by chemical composition, conditions of precipitation (artificial aging), amount of cold deformation, amperage and duration of welding. The formation of the structure and properties of the cold drawn wire is influenced also by smaller particles (carbides, nitrides, carbon-nitrides, etc.) which are formed in the solid steel during various solid phase transformations. [3]

It means that there is a necessity to use drown wire with over ductility to save standard properties (according to EN 10080).

Many difficulties had been encountered in achieving this goal, but solved after investigation and parameter corrections in every production process phase.

Steel billets with C_{eq} lower than 0,12% was produced and selected in steel plant (quality grade SAE1006 or C4D). Hot rolled wire from wire rod mill was processed using corrected technology. In cold drawing phase, the amount of diameter reduction was slightly decreased (average 22%). Drown wire properties, among them over ductility, were obtained and given in Table 3.

Table 3. Properties of cold drawn wire with diameter 7 mm produced using corrected technology.

Number of sample	Diameter reduction, %	$R_{p0,2}$, N/mm²	R_m, N/mm²	$R_m/R_{p0,2}$	A_{gt}, %
CT - 1	21,60	561	595	1,06	4,5
CT - 2	22,44	564	599	1,06	4,8
CT - 3	21,99	563	599	1,06	4,9
CT - 4	21,99	533	575	1,08	3,9
CT - 5	22,13	529	605	1,14	5,4
CT - 6	22,95	531	573	1,08	3,7
CT - 7	21,69	551	596	1,08	4,8
CT - 8	21,69	560	599	1,07	5,2
CT - 9	22,44	539	577	1,07	4,0

After welding wires with over ductility to form lattice girders (type 5), percentage total elongation at maximum force (A_{gt}) and tensile strength/yield strength ratio ($R_m/R_{p0,2}$) remained high enough as it shown in Table 4.

Table 4. Mechanical properties of upper chord and two lower chords lattice girder type 5 after welding drawn wire Φ7 mm produced using corrected technology.

Testing results	$R_{p0,2}$, N/mm²	$R_m/R_{p0,2}$	A_{gt}, %
Minimum value x_{min}	540	1,05	2,6
Average value of test results X	574	1,06	3,4
Maximum value x_{max}	605	1,07	4,3
Characteristic and minimal values according to EN 10080:2005	475	1,03	2,0
Characteristic and average values according to EN 10080:2005	510	1,05	2,5

Improving of lattice girders properties is result of using cold drawn wire produced with corrected technology. Improved cold dravn wire with diameter 7 mm has a certain degree of over quality in ductile properties as it shown in figure 2.

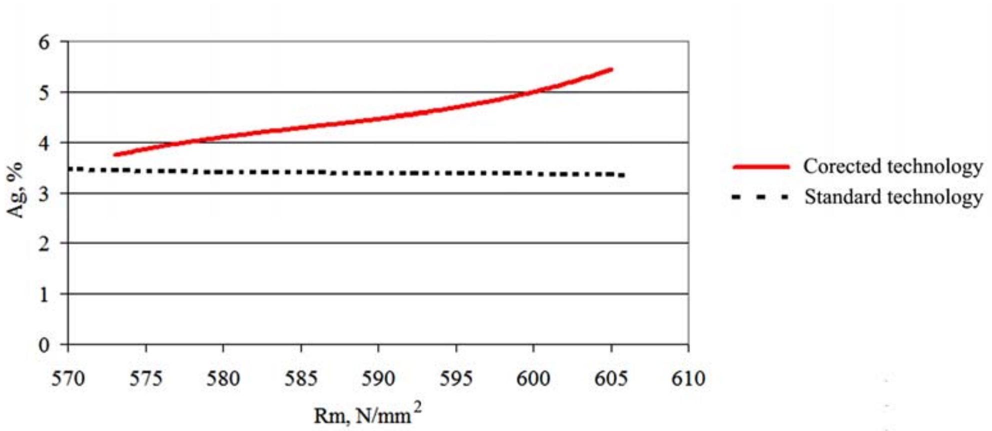

Figure 2. R_m and A_{gt} properties of cold drawn wire with diameter 7 mm produced using standard and corrected technology.

3. CONCLUSIONS

Practical application of the lattice girder production technology is shown that properties of the lattice girders are significantly affected by chemical composition, conditions of precipitation, levels of cold deformation, amperage and duration of welding. Compared to the hot-rolled steel, the cold-formed wire has a lower ratio between tensile strength and yield stress and a lower elongation at maximum load. All required mechanical properties of cold rolled wire could to be providing with a certain degree of over-quality in ductile properties. The capacity of lattice girder improving quality is in optimising of cold drawing levels, decreasing C_{eq} and welding parameters.

4.REFERENCES

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