

Mechanical Characterization And Tensile Behavior Of SS316L Bars: Comparative Study With Reported Literature

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Abstract:

In this research, the mechanical and tensile properties of commercially supplied SS316L stainless steel bars were studied, with comparative results reported in the literature. Specimens machined from cylindrical rods (ϕ 20 mm $\times$ 410 mm) were machined using high-speed steel tools and tested in accordance with standards ASTM E8/E8M on a servo-controlled Universal Testing Machine. The results from the tensile test revealed ultimate tensile strengths (UTS) from 601–693 MPa, yield strengths from 591–687 MPa, and an elongation of 9–12%. The range of strength values was found to be consistent with those reported in previous literature (Sharma et al., 2024, Mishra et al., 2024 and Maharaja et al., 2023); however, elongation is significantly lower than the typical range reported in literature between 20% – 40% elongation, a finding that indicates a potential decrease in ductility. It is believed that the reduction in elongation and increase in brittleness is the result of residual stresses, surface defects, or differences in microstructure associated with processing by the supplier. Although the variation from the typical literature elongation reported could be considered a reduction in ductility, anyway exhibited considerable and stable plastic deformation prior to fracture along with a ductile mode of failure. Overall supplied SS316L bars have high strength, and stable plasticity classifies them to be viable for applications where high strength and corrosion resistance is more important than ductility, such as structural components or marine, chemical, or biomedical applications. This study has established a baseline for the mechanical reliability of SS316L bars and will be possible to study the microstructure and post-processing options that may enhance the elongation of the bars to facilitate wider industrial applications.

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I. Introduction

Stainless steel 316L (SS316L) is an austenitic stainless steel, commonly used in structural applications, biomedical applications, and in nuclear engineering applications due to its favorable properties such as high temperature stability, toughness, and scope of corrosion resistance[1]. The mechanical properties- tensile strength, yield strength, and elongation- are sensitive to the processing, post-processing, and residual stress. All of these properties need to be approached with an understanding of reliable engineering performance in extreme service conditions- including roles in chemical processing, marine, medical implants and nuclear applications[2].

Tensile properties of SS316L are defined as elastic deformation, yielding, plastic deformation and fracture. Processing differences, such as rolling, heat treatment, or additive manufacturing, will modify the microstructure and have a measurable effect on both strength and ductility[3], [4]. Unfortunately, generally decreased ductility with a higher degree of microstructure refinement will improve tensile strength[5]. Residual stresses and surface defects are often overlooked but could contribute to shortened elongations even in full compliance with tensile standards. Indeed, reported mechanical properties for SS316L effectively range from 550 - 700 MPa in tensile strength and 10 - 40% elongation, without end based on material and process[6], [7].

This study will define the tensile properties of SS316L bar samples experimentally, emphasizing elastic and plastic deformation, yield point, ultimate tensile strength, and failure behavior. When compared with the mechanical properties listed in previous sections, the research will provide early insight into the mechanical reliability of the material and subsequent suitability for light frame metal structure applications.

Both additive manufacturing and conventional processing techniques can have a large impact on the microstructure and the tensile performance of the SS316L alloy. Sharma et al. (2024) reported that after additive processing, 316L stainless steel has high tensile strength attributed to a refined micro-structure[4]. A review by D.D. (2023) specifically notes that processing parameters and/or post-processing procedures had clearly

demonstrated influence the balance between ductility and strength of 316L alloys[8]. In the same manner, Mishra et al. (2024) reported improvements to fatigue and fracture behavior of SS316L alloys after suitable heat treatment[7].

For conventionally wrought SS316L, Ben Rhouma et al. (2019) studied the influence of machining on residual stresses and its implications for corrosion resistance[9]. Maharaja et al. (2023) conducted tests comparing strain-controlled fatigue at varying temperature, and their results demonstrated ductility loss at low temperatures[10]. Lai et al. (2021) researched fatigue strength reduction in laser powder bed fusion due to residual stresses[11].

Dynamic studies conducted by Zięta et al. (2020) displayed differences in deformation behaviour for conventionally manufactured SS316L compared to additively manufactured SS316L[12]. Furthermore, Saleh et al. (2016) also displayed damage and hardness profiles for irradiated SS316L, which further demonstrated the sensitivity of SS316L to service conditions[13]. More recently, Pagan et al. (2025) showed improvements in strength of cold-spray processed SS316 as porosity levels reduce[14].

For all previously mentioned studies, collectively demonstrate that SS316L exhibits tensile strengths between 550–700 MPa and elongation ranges between 10–40%, which depend on processing and testing conditions.

II. Material And Methods

Specimen formation

Austenitic Stainless Steel SS316L was chosen as the material for this study because it exhibits good corrosion resistance, high strength, and weldability. This material is also used in marine, biomedical and structural environments. The raw material was obtained from a supplier in the form of a solid cylindrical rod with a diameter of 20 mm and length of 410 mm. High-Speed Steel (HSS) tools were used for machining operations owing to their high hardness, wear resistance, and thermal conductivity, enabling precise cutting at elevated temperatures. For machining operations, High Speed Steel (HSS) was chosen for the tool material. HSS is a cutting tool material due to its high hardness, wear resistance and high thermal conductivity. HSS cutting tools allow for precise machining and sharp cutting edges at elevated temperatures. The machining operation setup is illustrated in Figs. 2 and 3, while the final prepared specimen is shown in Fig. 4, providing a complete overview of the experimental arrangement and sample preparation,



Figure 1. Lathe Machine



Figure 2. Operations during Specimen Formation



Figure 3. Final Specimen

Mechanical Properties and Dimensions

The mechanical properties and dimensions of each sample used in this research are presented in Table II. The table describes the material and actual dimensions of the work piece and tooling. The dimensions and materials in the tables are useful to understand the experiments.

Table 1: Mechanical Properties and Dimensions

S. No.	Material Type	Material	Dimensions
1.	Workpiece	SS316L Stainless Steel	ϕ 20 mm $\times$ 410 mm (raw stock)
2.	Tool	High Speed Steel (HSS)	

Experimental Setup

The samples were machined on a conventional lathe machine using a facing tool, turning tool, and chamfering tool. All machining was performed with the cutting parameters held constant to minimize thermal distortion or dimensional variation. Tensile testing was performed on the samples after machining using a Universal Testing Machine (UTM).

Machines and Accessories Used

- Lathe Machine (Conventional)
- 3-Jaw Chuck
- Facing Tool
- Step Turning Tool
- Chamfering File
- Vernier Caliper, Micrometer
- Universal Testing Machine (Model: TUE-C-1000 SERVO)

Specimen Preparation Procedure

1. A round bar of SS316L Stainless Steel (diameter 20 mm, length 410 mm) was prepared for specimens cutting.
2. Center Drilling was completed to deal with alignment.
3. Facing was accomplished on either side of the specimen for flatness purposes.
4. The method Step Turning was used to progressively decreased the diameter to the correct gauge section.
5. Chamfering, to smooth the specimen ends and prevent stress concentration, was accomplished by using a file.
6. The specimens were visually inspected and test after.

Final Specimen Dimensions

The specifications of all the specimens used in this study are presented in Table III. A dimension table of the specimens was necessary not only to keep measurements and specimens consistent, but also because the dimensions are an important aspect of the experimental setup that must be consistent to guarantee reliable and reproducible results.

Table 2: Specimen Dimensions

S No.	Parameter	Value Range
1	Specimen Shape	Solid Round Bar
2	Gauge Diameter	10.8 mm – 11.0 mm
3	Gauge Length	60.0 mm – 61.46 mm
4	Cross-Sectional Area	91.609 mm ² – 93.313 mm ²
5	Maximum Elongation Capacity Set	250 mm
6	Material Grade	SS316L Stainless Steel

Tensile Testing Procedure

The tensile tests were performed using servo-controlled Universal Testing Machine (UTM) as per Ambay Testing Solutions Pvt. Ltd., Lucknow. The UTM was calibrated according to standard procedures and operated at room temperature. The load was progressively applied until fracture occurred for each specimen. The load versus crosshead displacement curve was recorded for each specimen. The testing procedures followed ASTM E8/E8M. The Universal Testing Machine setup is presented in Fig. 5



Figure 5: Tue-C-1000 Computerized Universal Testing Machine

III. Result

The tensile test that was performed on the SS316L bar from the supplier exhibited the characteristic stages of deformation seen in ductile metals. In the elastic region, the specimen obeyed Hooke's law and exhibited a linear stress-strain response to the yield location. Yielding occurred at around 64.58 kN and 5.57 mm travel, indicating the first occurrence of permanent deformation. After this, the bar reached its ultimate tensile strength (UTS) at approximately 64.58 kN and 6.36 mm travel signifying that necking had already begun. The specimen recorded a gradual decrease in load during the plastic deformation stage until final fracture, approximately 11.29 mm travel occurred indicating a ductile mode of fracture. All stages are summarized in Table 3.

Table 3: Tensile Test Stages of SS316L Bar

S No.	Stage	Load (kN)	Travel (mm)	Remarks
1	Elastic Region	0 – ~64.6	0 – ~5.57	Linear; obeys Hooke's Law
2	Yield Point	~64.6	~5.57	Start of permanent deformation
3	UTS	Peak at 64.6	~6.36	Max load; necking starts
4	Plastic Deformation	Gradual drop	6.36 – ~11.29	Non-linear; ductile necking
5	Fracture	Sudden drop	~11.29	Final failure; ductile fracture

The mechanical properties of SS316L bar reported in Table 3 showed a tensile strength of 601.1–692.7 N/mm² and a yield strength of 590.8–686.5 N/mm². The elongation results were lower (9.09–11.75%) than anticipated based on the literature (20–40%) which indicates that this material has limited ductility. The limited elongation may have been influenced by processing conditions used by the supplier, e.g. rolling, heat treatment, or residual stresses during the manufacturing process. That said, the tensile strengths agreed with values reported in the literature (Sharma et al., 2024; Mishra et al., 2024; Maharaja et al., 2023) indicating the structural integrity for the material was supported [4], [10], [15].

Mechanical Properties

The tensile test outcomes for SS316L specimen procured from supplier has shown difference in mechanical performance between both samples. The ultimate tensile strength (UTS) as detailed in Table 4, showed the tensile strength ranging from 601.1 N/mm² to 692.7 N/mm², with yield strength between 590.8 N/mm² and 686.5 N/mm². The elongation measured between 9.09% to 11.75%, denoting reasonable ductility.

These results indicate high strength with reasonable elongation for both samples indicating the high strength material condoned high loads before failing. The observed differences in the strength and elongation between both samples can be attributed to small differences in microstructure, machining accuracy and localised residual stresses developed during the sample preparation. Overall, the measured, consistent with mechanical behaviour of reported SS316L stainless steel, was measured in a reasonable range for this material.

Table 4: Tensile Properties of SS316L Specimens

S No.	Sample	Tensile Strength (N/mm ²)	Yield Strength (N/mm ²)	Elongation (%)
1	Sample	601.1	590.8	9.09
2	Sample	692.7	686.5	11.75

The results of the tensile test performed on the SS316L square bar received from the supplier showed an ultimate tensile strength (UTS) ranging from 601-693 MPa and elongation of 9-12%, which fall within the scope established by the literature. As presented in Table 5, Sharma et al. (2024, Springer) and Mishra et al. (2024, Elsevier) reported a UTS range of 600-700 MPa and 650-700 MPa, which supports the strength values exhibited in the current work[4], [15]. However, the elongation obtained in this study is considerably lower than the literature reports of 20-40%, indicating ductility is decreased. Similar trends noted in the comparisons with Tucho et al. (2018, Elsevier) and Ben Rhouma et al. (2019, Springer) indicated ductility values of approximately 28-35% to be higher than those of the current sample[9], [16]. This reduced elongation may be a result of the machining process and residual stresses developed during service, as stated in Ben Rhouma et al. (2019)[9]. Additionally, Aziz et al. (2025, PMC Review) proposed that porous and microstructure defects could have an impact on the reduction of ductility and may have played a role in the results presented in the current study[17]. In conclusion, as presented in Table 5, while the UTS closely match the published results, the manufacturing method itself appears to impact ductility of the present SS316L supplies.

Table 5: Comparison of experimental results with literature data for SS316L

Reference	Reported UTS (MPa)	Reported Elongation (%)	This Work (Supplier Bar)	Remarks
Sharma et al., 2024 (Springer)	600–700	30–40	601–693 / 9–12	Strength matches, elongation lower
Mishra et al., 2024 (Elsevier)	650–700	20–35	601–693 / 9–12	Strength consistent, ductility reduced
Tucho et al., 2018 (Elsevier)	~600	~30	601–693 / 9–12	Strength similar, ductility reduced
Ben Rhouma et al., 2019 (Springer)	~620	28–35	601–693 / 9–12	Machining/residual stress reduces ductility
Aziz et al., 2025 (PMC Review)	550–700	25–40	601–693 / 9–12	Porosity/defects can lower elongation
Dolzhenko et al., 2022 (MDPI Metals)	650–720	30–35	601–693 / 9–12	Matches high-strength values
Maharaja et al., 2023 (Elsevier)	600–680	20–30	601–693 / 9–12	Strength same, elongation resembles low-T behavior
Present Study	601–693	9–12	—	Supplier method reduces ductility

(Table compiled from multiple sources including Sharma et al., 2024; Mishra et al., 2024; Tucho et al., 2018; Ben Rhouma et al., 2019; Aziz et al., 2025; Dolzhenko et al., 2022; Maharaja et al., 2023)

Application Perspective

Although there is a decrease in ductility, the high strength and yield strength of the tested SS316L bar qualify it for use where strength and resistance to corrosion are more important than ductility. Some common examples are:

1. Structural applications for chemical plants and food processing units (due to corrosion resistance).
2. Offshore and marine components (strength and corrosion resistance against chlorides).
3. Nuclear reactor core materials (Sharma et al., 2024; Core Materials, 2011)[4], [18].
4. Surgical instruments and implants where strength is a critical requirement but elongation demands are less.
5. Components in power plants with high loads where thermal and mechanical stability matter over high ductility.

But in applications where high formability and toughness are demanded (e.g., deep drawing, sheet forming, or dynamic fatigue loading), the lower elongation seen in the provided bar can make it less fit for purpose.

IV. Conclusion

The current study assessed the mechanical properties and tensile performance of commercial SS316L stainless steel rods. Ultimate tensile strength (UTS) was reported as 601 - 693 MPa, yield strength was reported as 591 - 687 MPa, and elongation was noted at 9 - 12%. The values obtained for tensile and yield strength are similar to those reported in the literature (Sharma et al., 2024; Mishra et al., 2024; Maharaja et al., 2023) supporting the strength and structure of the material [10], [15], [19].

The elongation reported was considerably lower than published literature, which have reported 20% - 40%, and indicates reduced ductility. The reduction in elongation may be from residual stresses, surface defects, or microstructural variations that occurred from the rolling or machining process done by the supplier. Overall, the bars were observed to demonstrate stable plastic deformation and fracture in a ductile mode imparting confidence in its use in applications which require high-strength yet corrosion-resistant properties, such as used in marine, chemical, and structural uses and where elongation is not a primary performance consideration.

In conclusion, the SS316L bars from the supplier demonstrated excellent strength values for moderate ductility and met minimum engineered performance expectations. Future work will include microstructural and fractographic observations to correlate mechanical performance characteristics to internal structure features observed, and evaluation of post-processing or heat treatment specifications to understand how to improve ductility and broaden potential applications for industrial use.

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