Jurnal Teknik Mesin, Industri, Elektro dan Informatika
Volume 5, Nomor 3, September 2026
e-ISSN: 2963-7805; p-ISSN: 2963-8208, Hal. 343-353
DOI: https://doi.org/10.55606/jtmei.v5i3.6455
Tersedia: https://ejurnal.politeknikpratama.ac.id/index.php/jtmei

Investigation of Discrepancies in Tensile Test Results of G550 Galvanized Steel Between Manufacturer Laboratory and an Independent Laboratory

Rudi Suhradi Rachmat[1*], Ogawa Muneshige[2], Sigit Sejati[3], Stevanus Fransiscus[4]
[1] Mechanical Engineering, President University, Indonesia
[2] NIPPON STEEL Co.Ltd, Japan
[3, 4] FUMIRA Co.Ltd, Indonesia
Email: rudi.sr@president.ac.id[1], ogawa.muneshige.8kc@eng.nipponsteel.com[2], sigit.sejati@fumira.co.id[3], steve.fransiscus@fumira.co.id[4]

*****Corresponding Author: rudi.sr@president.ac.id

Abstract. Mechanical property testing is a primary method for ensuring the quality of galvanize steel manufacture by continuous galvanizing line (CGL), products used in lightweight construction. This study aims to analyze the causes of discrepancies in tensile test results between Manufacturer Laboratory and Independent Testing Laboratory, which was conducted at the request by customer. The differences in test results raised concerns that the product did not meet the G550 specifications as stated in the Mill Test Certificate (MTC). The investigation was carried out by evaluating specimen preparation methods, conducting interlaboratory comparison tests, and analyzing both mechanical test results and chemical composition. The findings indicate that the differences in Yield Strength and Ultimate Tensile Strength values were primarily caused by the use of non-standard specimen shapes resulting from manual cutting with hand scissor. This condition led to inaccurate calculations of the effective cross-sectional area and caused fractures to occur outside the gauge length, rendering the test results unrepresentative. After retesting using standard specimens prepared with a punch press, the results were consistent and met the requirements for G550 grade steel. This research demonstrates that the quality of specimen preparation is a critical factor in ensuring the validity of mechanical test results.

Keywords: G550 Steel; Quality Control; Specimen Preparation; Tensile Test; Yield Strength.

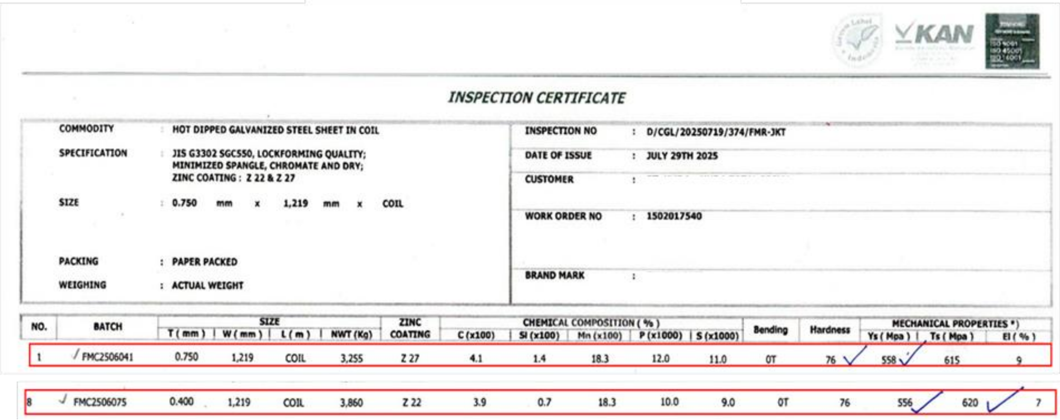
1. INTRODUCTION

Galvanize steel manufacture by continuous galvanizing line (CGL) is widely used in the light steel construction industry due to its high strength, good corrosion resistance, no rust reaction with cement or concrete and ease of fabrication (Choi et al., 2023; Simanjuntak et al., 2024; Yeomans, 2023). One of the most important quality parameters is its mechanical properties, namely Yield Strength, Ultimate Tensile Strength, and elongation (Hou et al., 2022; Zhu et al., 2026).

Tensile testing is performed according to international standards such as ASTM E8/E8M or ISO 6892-1 (Silalahi et al., 2021; ZwickRoell, 2024; 高怡斐 & 梁新帮, n.d.), using specimens with specific dimensions to ensure uniform stress distribution during loading. Figure 1, we attach the tensile test results written from manufacture MTC document.

Manufacturer of galvanize steel, issues a Mill Test Certificate (MTC) containing the mechanical test results for each production batch (Tomić et al., 2025). The customer filed a complaint because the re-test results conducted at independent testing laboratory showed values that differed from the MTC.

Naskah Masuk: 02 Mei 2026; Revisi: 07 Juni 2026; Diterima: 03 Juli 2026; Tersedia: 13 Juli 2026



INSPECTION CERTIFICATE

COMMODITY : HOT DIPPED GALVANIZED STEEL SHEET IN COIL
SPECIFICATION : JIS G3302 SGC550, LOCKFORMING QUALITY; MINIMIZED SPANGLE, CHROMATE AND DRY; ZINC COATING : Z 22 & Z 27
SIZE : 0.750 mm x 1,219 mm x COIL
PACKING : PAPER PACKED
WEIGHING : ACTUAL WEIGHT

INSPECTION NO : D/CGL/20250719/374/FMR-JKT
DATE OF ISSUE : JULY 29TH 2025
CUSTOMER :
WORK ORDER NO : 1502017540
BRAND MARK :

NO.	BATCH	SIZE T (mm)	W (mm)	L (m)	NWT (Kg)	ZINC COATING	CHEMICAL COMPOSITION (%) C (x100)	SI (x100)	Mn (x100)	P (x1000)	S (x1000)	Bending	Hardness	MECHANICAL PROPERTIES *) Ys (Mpa)	Ts (Mpa)	El (%)
1	FMC2506041	0.750	1,219	COIL	3,255	Z 27	4.1	1.4	18.3	12.0	11.0	0T	76	558	615	9
8	FMC2506075	0.400	1,219	COIL	3,860	Z 22	3.9	0.7	18.3	10.0	9.0	0T	76	556	620	7

Figure 1. MTC Galvanize Iron the Thickness 0.75 mm and 0.45 mm.

This discrepancy raised the question of whether the cause originated from material quality or from the testing methodology. Therefore, an investigation was conducted through an interlaboratory comparison test between manufacturer internal laboratory and an independent laboratory, paying close attention to the conformity of specimen preparation with testing standards.

2. EXPERIMENTAL PROCEDURE

Material

The material used was G550 grade zinc-coated steel produced by manufacturer (Tan et al., 2025; Young & Ellobody, 2023), consisting of two coils that were the subject of the complaint: (1) Thickness 0.75 × 1219 mm; (2) Thickness 0.40 × 1219 mm. In addition to these two coils, testing was also performed on several other production batches for comparison.

Subsection 2

Testing was conducted using a Universal Testing Machine (UTM) in accordance with standard procedures for tensile testing of metals (A653/A653M-11, 2011; ZwickRoell, 2024; 高怡斐 & 梁新帮, n.d.). The parameters evaluated included: (1) Yield Strength (YS); (2) Ultimate Tensile Strength (UTS); (3) Elongation (%).

Initial Testing

The initial testing was performed by independent laboratory using specimens that had been cut manually using scissor. Characteristics of the specimens: 1) Asymmetrical shape; 2) Non-uniform specimen width; 3) Plastic deformation at the cut edges; 4) Did not comply with ASTM E8 or ISO 6892 standards.

Retesting (Round Robin Test)

To confirm the cause of the discrepancies, retesting was carried out using the following procedure: (1) Customer reshipped the material; (2) Manufacturer cut the specimens using a standard punch and die machine evident by customer; (3) The specimens were sent back to the same independent laboratory again; (4) Tensile testing was conducted again evident by manufacturer and customer; (5) Chemical composition analysis was performed using an Optical Emission Spectrometer.

Figure 2. Photo sample with a thickness of 0.75 mm conducted in an independent laboratory

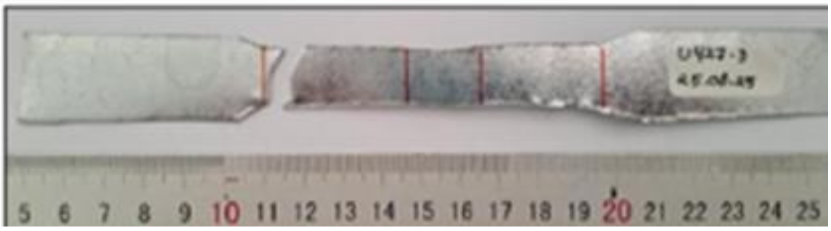


Figure 3. Photo sample with a thickness of 0.45 mm conducted in an independent laboratory

3. RESULT AND ANALYSIS

Intial Test Results

The initial tests revealed a significant difference between the results from manufacturer MTC and those from the independent Laboratory as shown figure 2 and figure 3.

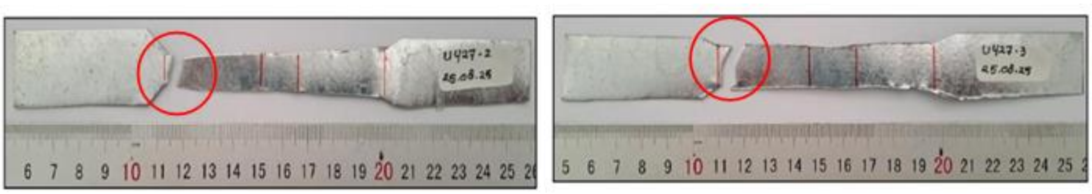
Table 1. Tensile test results with a thickness of 0.75 mm conducted in an independent laboratory.

Test Parameter	Test Result
Thickness (mm)	0.75
Length (mm)	10.81
Surface Area (mm^2)	8.76
Tensile Strenth (N/mm^2)	454.34
Yield Strenth (N/mm^2)	407.68
Initial Length (mm)	50
Final Length (mm)	51.2
Strain (%)	2.4

Table 2. Tensile test results with a thickness of 0.45 mm conducted in an independent laboratory.

Test Parameter	Test Result
Thickness (mm)	0.45
Length (mm)	13.72
Surface Area (mm2)	8.76
Tensile Strenth (N/mm2)	464.58
Yield Strenth (N/mm2)	279.7
Initial Length (mm)	50
Final Length (mm)	51.28
Strain (%)	2.56

Furthermore, several anomalies were observed: (1) Lower Yield Strength values; (2) Lower Ultimate Tensile Strength values; (3) Elongation values also decreased. Theoretically, this condition is unusual because if the Yield Strength decreases, plastic deformation typically increases, so elongation should ideally rise as show table 1 and table 2. This phenomenon indicated an error in the testing methodology.



(a) (b)

Figure 4. Photo sample with a thickness of 0.45 mm (a) and 0.75 mm conducted in an independent laboratory, show broken at outside gauge length (b).

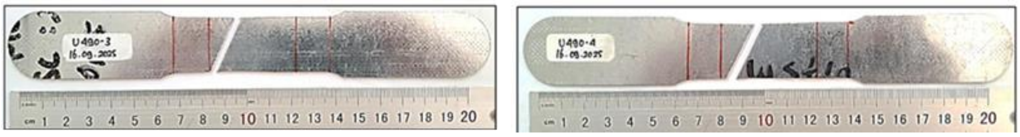
Evaluation of Specimen Shape

Observations at figure 4 showed that the samples 0.45mm and 0.75 mm break location is outside the gauge length. Because samples were cut manually and therefore did not meet standard requirements. Consequently: (1) The actual cross-sectional area could not be precisely determined; (2) Stress distribution became non-uniform; (3) Stress concentration occurred at certain points; (4) Fracture occurred outside the gauge length. A fracture outside the gauge length technically categorizes the test as an invalid test or a broken sample, meaning the data obtained cannot be used as a representation of the materials mechanical properties.

Interlaboratory Comparison Test Results

Figure 5 describes Standard tensile test sample follow international standards such ASTM E8/E8M or ISO 6892-1, the samples sent to an independent laboratory for re- testing as shown at figure 6 and figure 7. To ensure certainty, samples are retested in the presence of the manufacturer and customer.

Figure 5. Standard tensile test sample shape. Cut using a punch machine with special dies.



(a) (b)

Figure 6. Tensile test sample with a thickness 0.45 mm conducted in manufacturer laboratory (a) and an independent laboratory, show broken at outside gauge length (b).

(a) (b)

Figure 7. Tensile test sample with a thickness 0.75 mm conducted in manufacturer laboratory (a) and an independent laboratory, show broken at outside gauge length (b).

Table 3. Tensile test results with a thickness of 0.45 mm conducted in an independent laboratory.

Test Parameter	Test Result at Manufacturer	Test Result at Independent Lab
Thickness (mm)	0.45	0.45
Length (mm)	25.03	25.03
Surface Area (mm^2)	11.01	11.01
Tensile Strenth (N/mm^2)	658.51	664.27
Yield Strenth (N/mm^2)	658.31	653.31
Initial Length (mm)	50.00	50.00
Final Length (mm)	51.71	52.08
Strain (%)	3.42	4.16

Table 4. Tensile test results with a thickness of 0.45 mm conducted in an independent laboratory.

Test Parameter	Test Result at Manufacturer	Test Result at Independent Lab
Thickness (mm)	0.75	0.75
Length (mm)	25.01	25.01
Surface Area (mm^2)	19.51	19.26
Tensile Strenth (N/mm^2)	684.68	673.9
Yield Strenth (N/mm^2)	658.28	655.61
Initial Length (mm)	50.00	50.00
Final Length (mm)	53.59	55.00
Strain (%)	7.18	10.00

After the specimens were cut using a punch press to standard dimensions, the retest results showed at table 3 and table 4: (1) Yield Strength met G550 specifications; (2) Ultimate Tensile Strength met G550 specifications; (3) The fracture location was within the gauge length; (4) The test results were consistent with manufacturer MTC. Thus, it can be concluded that the material produced by manufacturer still meets the required quality specifications.

Chemical Analysis Results

Chemical composition testing on several batches showed that the content of elements: (1) Carbon (C) 0.04%; (2) Silicon (Si) 0.014%; (3) Manganese (Mn) 0.01%; (4) Phosphorus (P) 0.0012%; (5) Sulfur (S) 0.0011%. Were within the specification range for high-grade G550 steel. Minor variations between batches were still within production process tolerances and therefore did not significantly affect the material's mechanical properties.

Discussion

Tensile testing is a method highly sensitive to specimen geometry. Stress values are calculated using the equation 1 (Abedini et al., 2022; Mihalache et al., 2025; Silalahi et al., 2024):

$$\sigma = \frac{F}{A} \quad \text{...(1)}$$

Where:

σ = stress (MPa)

F = maximum force

A = initial cross-sectional area (mm²)

If specimens are cut manually, the actual cross-sectional area becomes non-uniform, leading to deviations in the calculated Yield Strength and Ultimate Tensile Strength values (Committee, 1990).

Additionally, the edges resulting from manual cutting can create stress concentrations that may cause premature cracking before the material reaches its maximum capacity (Diouf et al., 2026; Gdoutos & Konsta-Gdoutos, 2024). The investigation clearly demonstrates that the discrepancies in the tensile test results were not a reflection of material quality but a direct consequence of non-standard specimen preparation (Kardak et al., 2017; Mahaputra et al., 2022). The initial tests performed by the independent laboratory, using manually cut specimens, produced Yield Strength (YS) and Ultimate Tensile Strength (UTS) values significantly below the G550 specification and the manufacturer's Mill Test Certificate (MTC) (Gao et al., 2024). In contrast, the results from the subsequent round-robin tests, which used specimens prepared with a punch press according to standard dimensions, were consistent and met all requirements. This points to specimen geometry and preparation as the primary variables affecting the test outcome.

The root cause of the initial failure can be explained by several interconnected factors. Firstly, manual cutting with hand scissors introduces significant geometric irregularities. The stress (σ) in a tensile test is calculated by dividing the applied force (F) by the initial cross-sectional area (A) [$\sigma = F/A$]. If the specimen width is non-uniform, the effective cross-sectional area cannot be accurately determined, leading to an incorrect calculation of stress. International standards like ISO 6892-1 and ASTM E8/E8M explicitly require that specimen preparation does not influence the material properties, which is impossible to guarantee with manual methods that create asymmetric and non-uniform shapes (BalduzziGiuseppe et al., 2021).

Secondly, the cutting process itself is a source of defects. The edges of specimens cut with scissors are prone to plastic deformation, burrs, and even microscopic cracks. These imperfections act as "stress raisers" or points of stress concentration (BalduzziGiuseppe et al., 2021; Budiyanto et al., 2024). The stress at these discontinuities can be significantly higher than the nominal stress calculated for the bulk of the specimen. During tensile loading, a crack can initiate at these stress raisers, leading to premature failure before the material reaches its actual yield or tensile strength. The magnitude of this effect is well-documented; studies have shown that the geometry of the specimen, particularly the fillet radius in the transition region, directly influences the stress concentration factor and, consequently, the measured failure strength (Osamura et al., 2014). Even a small variation in geometry can lead to substantial differences in stress distribution and premature failure . This is the most likely explanation for the anomalously low values observed in the independent laboratory's initial tests.

The consequence of this premature failure is often a fracture occurring outside the gauge length (the section of the specimen where strain is measured). This was a critical anomaly observed in the initial tests. As noted in the analysis, a fracture outside the gauge length renders the test invalid because the deformation and strain measured are not representative of the material's behavior over the intended section. Standards state unequivocally that the result is valid only if the fracture and necking occur within the extensometer gauge length . When fracture occurs outside this zone, the calculated elongation is often lower than the true value. This directly explains the unusual and contradictory data where both the strength and elongation values were depressed (Osamura et al., 2010). The problem of specimens breaking outside the gauge section is a recognized challenge in materials testing, leading to high rates of invalid tests and increased costs.

The consistency achieved in the retests confirms that the material itself is sound. The interlaboratory comparison (or round-robin test) is a well-established method for verifying testing accuracy. By having multiple laboratories test specimens from the same sample, variations in methodology can be identified and isolated, and the major source of scattering in measured values can be attributed to inter-laboratory differences . In this case, the round-robin test was essential in proving that the material met specifications once the correct preparation method was used. The fact that chemical composition analysis showed the material to be within specification further reinforces that the performance issue was isolated to the testing procedure, not the material quality.

Therefore, the investigation serves as a powerful case study on the critical importance of strict adherence to testing standards. The quality of the final data is only as good as the quality of the specimen preparation. This is particularly true for thin, light-gauge steel, where the material is sensitive to any deformation or damage introduced during preparation. The findings from this study underscore the necessity of using standardized methods, such as precision punch presses, to ensure that test results are valid, repeatable, and truly represent the material's mechanical properties.

4. CONCLUSIONS

Based on the investigation, it can be concluded that: (1) The discrepancies in tensile test results between manufacturer and the independent laboratory were not caused by material quality, but rather by the specimen preparation method. (2) Specimens produced by manual cutting did not meet tensile testing standards, resulting in unrepresentative values for Yield Strength, Ultimate Tensile Strength, and elongation. (3) Retesting using standard specimens prepared with a punch press produced data consistent with manufacturer Mill Test Certificate. (4) All tested materials still met the specifications for high-grade G550 steel. (5) All tested materials still met the specifications for high-grade G550 steel. To ensure the validity of mechanical test results, specimen preparation must adhere to ASTM E8/E8M or ISO 6892-1 standards.

REFERENCES

A653/A653M-11, A. (2011). *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvan-nealed) by the Hot-Dip Process*.

Abedini, A., Narayanan, A., & Butcher, C. (2022). An investigation into the characterization of the hardening response of sheet metals using tensile and shear tests with surface strain measurement. *Forces in Mechanics*, *7*, 100090. https://doi.org/10.1016/j.finmec.2022.100090

Balduzzi Giuseppe, Zelaya-Lainez Luis, Hochreiner Georg, & Hellmich Christian. (2021). Dog-bone Samples may not Provide Direct Access to the Longitudinal Tensile Strength of Clear-wood. In *The Open Civil Engineering Journal* (Vol. 15). Bentham Science. https://doi.org/10.2174/1874149502115010001

Budiyanto, S., Manduapessy, J. O., Silalahi, L. M., Hamid, A., & Hanafi, D. (2024). Wireless Sensor Network for Power Control and Monitoring Public Street Lighting with Earthquake Early Warning. *2024 FORTEI-International Conference on Electrical Engineering (FORTEI-ICEE)*, 235–240. https://doi.org/10.1109/FORTEI-ICEE64706.2024.10824353

Choi, J.-S., Choi, S.-W., & Lee, E.-B. (2023). Modeling of Predictive Maintenance Systems for Laser-Welders in Continuous Galvanizing Lines Based on Machine Learning with Welder Control Data. In *Sustainability* (Vol. 15, Issue 9, p. 7676). https://doi.org/10.3390/su15097676

Committee, A. S. M. I. H. (1990). *Properties and Selection--Irons, Steels, and High-performance Alloys* (Vol. 1). ASM international.

Diouf, F. M., Liegard, W., Tabourot, L., Sene, N. A., Roux, E., & Balland, P. (2026). Detection of early plasticity in steel using large scale 4-point bending. *Mechanics & Industry*, *27*, 17. https://doi.org/10.1051/meca/2026014

Gao, Z., Chen, X., Zheng, X., & Yang, L. (2024, April 9). *The Influence of Sample Geometry on the Mechanical Properties and Failure Mechanisms of 6111 Aluminum Alloy Tensile Specimens*. https://doi.org/10.4271/2024-01-2280

Gdoutos, E., & Konsta-Gdoutos, M. (2024). *Mechanical Testing of Materials* (Vol. 275). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-45990-0

Hou, Y., Zhang, W., Mi, X., Xie, H., Feng, X., Huang, G., Peng, L., & Yang, Z. (2022). Different response mechanisms of yield strength and ultimate tensile strength in pure copper considering size effect. *Materials Science and Engineering: A*, *849*, 143443. https://doi.org/10.1016/j.msea.2022.143443

Kardak, A. A., Bilich, L. A., & Sinclair, G. B. (2017). Stress Concentration Factors for ASTM E8/E8M-15a Plate-Type Specimens for Tension Testing. *Journal of Testing and Evaluation*, *45*(6), 2294–2298. https://doi.org/10.1520/JTE20160385

Mahaputra, F. A., Simanjuntak, I. U. V., Yuliza, Heryanto, Rochendi, A. D., & Silalahi, L. M. (2022). Comparative Study Of Convolutional Neural Network And Haar Cascade Performance On Mask Detection Systems Using Matlab. *2022 9th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, 74–78. https://doi.org/10.23919/EECSI56542.2022.9946467

Mihalache, M. A., Merticaru, V., Ermolai, V., Andrusca, L., Cimpoesu, N., & Negoescu, F. (2025). A Proposed System for Temperature Measurement During Tensile Testing. In *Sensors* (Vol. 25, Issue 17, p. 5494). https://doi.org/10.3390/s25175494

Osamura, K., Nyilas, A., & Shin, H. (2010). Estimation of uncertainty with the modulus of elasticity measured by means of tensile test for BSCCO tapes. *Cryogenics*, *50*(10), 660–665. https://doi.org/10.1016/j.cryogenics.2010.06.009

Osamura, K., Shin, H.-S., Weiss, K.-P., Nyilas, A., Nijhuis, A., Yamamoto, K., Machiya, S., & Nishijima, G. (2014). International round robin test for mechanical properties of REBCO superconductive tapes at room temperature. *Superconductor Science and Technology*, *27*(8), 85009. https://doi.org/10.1088/0953-2048/27/8/085009

Silalahi, L. M., Budiyanto, S., Silaban, F. A., Simanjuntak, I. U. V., Rochendi, A. D., & Osman, G. (2021). Optimizing The Performance Of The Power Station Generator Space Lighting System Performance Based On Internet Of Things Using ESP32. *2021 3rd International Conference on Research and Academic Community Services (ICRACOS)*, 219–224. https://doi.org/10.1109/ICRACOS53680.2021.9702010

Silalahi, L. M., Rafi Indrawan, M., Budiyanto, S., Hanafi, D., Hamid, A., & Ronaldo, D. (2024). Smart Home Control System Design using Internet of Things Based Energy Harvesting Technology. *2024 IEEE 6th Symposium on Computers & Informatics (ISCI)*, 43–48. https://doi.org/10.1109/ISCI62787.2024.10667797

Simanjuntak, I. U. V., Heryanto, H., Dani, A. W., Salamah, K. S., Silalahi, L. M., & Marsuki, M. (2024). Analysis Of Solar Power Public Street Lighting Optimization With Pvsyst Software In A Residential Complex Area. *International Journal of Electronics and Telecommunications*, *70*(3), 743–749.

Tan, C. S., Ling, P. C. H., & Moy, J. J. (2025). Incorporating New Generation Cold-Formed High-Strength Steel (CFHSS) to the Conformity of Present Product Standards. *International Journal of Steel Structures*, *25*(6), 1304–1314. https://doi.org/10.1007/s13296-025-01009-8

Tomić, T., Mihalic, T., Groš, J., & Vugrinec, L. (2025). Experimental Evaluation of Arc Stud Welding Techniques on Structural and Stainless Steel: Effects on Penetration Depth and Weld Quality. In *Applied Sciences* (Vol. 15, Issue 13, p. 7269). https://doi.org/10.3390/app15137269

Yeomans, S. R. (2023). 8 - Galvanized steel reinforcement: recent developments and future opportunities. In A. B. T.-C. of S. in C. S. (Second E. Poursaee (Ed.), *Woodhead Publishing Series in Civil and Structural Engineering* (pp. 161–186). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-821840-2.00005-5

Young, B., & Ellobody, E. (2023). Experimental investigation on cold-formed steel Z-sections having different stiffened flanges undergoing web crippling. *Engineering Structures*, *286*, 116144. https://doi.org/10.1016/j.engstruct.2023.116144

Zhu, J., Lin, Y., Li, C., Wang, N., Shi, B., & Zhang, Z. (2026). Predicting mechanical properties of as-rolled eutectic Mg-8Li alloy via machine learning. *Journal of Materials Science & Technology*, *254*, 45–60. https://doi.org/10.1016/j.jmst.2025.08.011

ZwickRoell, A. I. (2024). *ASTM E8/E8M-24: Standard Test Methods for Tension Testing of Metallic Materials*. USA: ASTM International, PA.

高怡斐, & 梁新帮. (n.d.). Evaluation on Measurement Uncertainty of Elastic Modulus According to ISO 6892-1: 2019 Annex G. *Physical Testing and Chemical Analysis Part A: Physical Testing*, *57*(4), 1–6.