

Development of A Fixed Drawing Table and Stool Unit for Engineering Drawing

NWIZUGBO, FERDINAND CHINEDUM¹, KOLO BABAZHITSU YETU², YISA JAMES SAIDU³,
IBRAHIM BATA MSHELIA⁴

^{1, 2, 3, 4}department Of Mechanical Engineering, Federal Polytechnic, Bida, Niger State

Abstract- This work presents the design, fabrication, and evaluation of a fixed drawing table and stool intended for use in academic and workshop environments. The design process incorporated structural analysis, ergonomic considerations, and material selection to ensure safety, comfort, and durability. Mild steel pipes of square cross-sections were used for the table and stool frames due to their high strength-to-weight ratio and availability, while medium-density fiberboard (MDF) was employed for the tabletop and seat surfaces because of its smooth finish and dimensional stability. Results from load and stress calculations performed showed that the table and stool safely withstood the design loads with bending and compressive stresses well below the allowable limits of MDF and mild steel, respectively. Stability, ergonomic, and surface finishing tests confirmed that the workstation met functional and safety requirements. The inclusion of a footrest enhanced user comfort. Furthermore, the use of flat bars to bind and fix the table and tool set with others has further fortified them as they will neither be easily moved/damaged, nor be easily carted away by thieves. The study concludes that the fabricated table and stool are structurally safe, ergonomically sound, and suitable for prolonged drawing activities.

Keywords: Drawing Table, Stool, Ergonomic, Fixed, MDF

I. INTRODUCTION

Engineering drawing is a universal language used by engineers, architects, and designers to communicate technical information clearly and precisely. It involves the use of standardized symbols, lines, dimensions, and projections to represent ideas and designs that can later be manufactured or constructed (Reddy, 2008). It provides necessary information about the shape, size, surface quality, material, manufacturing process, and so on of the object. This process requires not only the correct knowledge of drawing standards but also the availability of drawing instruments and suitable furniture to support the drafter during long hours of work. Engineering drawings are usually done with drawing instruments and equipment.

In addition to portable instruments, larger equipment like the drawing table (also known as a drafting table) and stool are equally important. The drawing table provides a large, stable surface often inclined at an ergonomic angle for drawing sheets, while the stool offers proper seating posture for the user (Salameh and Abdullahi, 2020). Ergonomics plays a critical role: research shows that poorly designed furniture contributes to musculoskeletal disorders such as back pain, neck strain, and wrist discomfort, especially when used over long periods (Bai *et al.*, 2024).

Drawing tables used for engineering and technical drafting vary according to portability, adjustability, ergonomic performance, and integration with digital tools. Common types include portable or folding tables, adjustable tilting tables, ergonomic automated drafting tables, traditional fixed wooden drafting tables, digital hybrid desks, split-top tables, artist's drafting tables, and glass-top light tables. Portable tables are valued for mobility and compactness, whereas adjustable and automated designs offer improved ergonomic flexibility through height and tilt control. Traditional fixed wooden tables remain widely used in educational settings because of their simplicity, durability, and affordability. More advanced models, such as digital hybrid and split-top tables, provide multifunctional work surfaces that support both manual and computer-aided design activities. Specialized tables, such as artist's drafting tables and glass-top light tables, are suited to high-inclination sketching, tracing, and layered visual work. Sitting options for drafting likewise range from simple fixed backless stools to more ergonomic adjustable-height, cushioned, and swivel stools. While adjustable and cushioned designs improve comfort and posture during prolonged use, ergonomic fixed stools are economical and durable.

II. AIM AND OBJECTIVES OF THE STUDY

The study aimed to design and construct a fixed drawing table and stool for engineering drawing applications, with the specific objectives of performing the necessary design calculations for both components, fabricating the table and stool using locally available materials, and subsequently installing and evaluating the completed design for load-bearing capacity and user comfort. The study is justified on the grounds that imported drawing tables and stools are often costly, whereas local fabrication offers a more economical and sustainable alternative. Furthermore, an ergonomically designed drawing table and stool could enhance students' comfort and improve learning outcomes during engineering drawing activities. In addition, the fixed configuration of the table and stool helps in minimizing unnecessary movement by students and preventing theft.

III. MATERIALS AND METHODS

3.1 Materials

For this work, mild steel square pipes were used for the framework, while MDF wood was used for the tops of the drawing table and stool. Other materials used in this project include: welding electrodes, screws, and filing rods. Mild steel was selected as the primary structural material for the drawing table and stool due to its favorable mechanical and practical properties. Its selection was based on its high strength and rigidity, its ability to withstand both tensile and compressive stresses, its relatively low sensitivity to heat during fabrication, and the comparatively low cost associated with joining and assembling its components. In addition, mild steel is readily available in the local market, requires minimal maintenance when used in the form of square and rectangular hollow sections, and is widely recognized for its durability and toughness in structural applications. For the table and stool tops, medium-density fibreboard (MDF) was chosen because of its suitability for furniture and drawing-surface applications. MDF is an engineered wood product produced from compressed wood fibres bonded with resin and wax under heat and pressure. It provides a smooth and uniform surface that is particularly suitable for engineering drawing activities. Its dimensional stability, resistance to warping, cracking, and significant moisture-induced

expansion or shrinkage, as well as its ease of cutting, drilling, and shaping without splintering, make it advantageous for fabrication. Furthermore, MDF offers adequate mechanical strength for light to moderate service loads, while remaining more economical than many solid hardwood alternatives. Its surface also permits lamination, veneering, or painting, thereby enhancing both durability and aesthetic quality.

3.2 Methods

3.2.1 Design Considerations

The design of any engineering component requires the consideration of many factors which aid in the accurate selection of materials needed to construct the work. They include mechanical properties, machinability, availability of material, choice of material, and wear resistance. Furthermore, the following were considered:

For calculation purposes, the draughtsman is assumed to weigh approximately 100 kg (≈ 981 N). However, only the hands, drawing paper, and drawing instruments rest on the table during normal use. Therefore, a working load of 150 N was adopted for normal service, while a conservative design load of 1000 N was used to account for accidental leaning or misuse. The table top dimensions are 1050 mm \times 600 mm (0.9 m²), and the table height is 790 mm. A factor of safety (F_s) = 2.5 was applied (Beer *et al.*, 2015). The table frame and legs are constructed from mild steel hollow square pipes of 25 mm \times 25 mm \times 2 mm, while the table top is made of 20 mm MDF board. The top of the stool measured 280mm \times 280mm. Material properties include:

Mild Steel - Ultimate tensile strength ≈ 400 MPa;
Yield strength ≈ 250 MPa (AZoM, 2012)

MDF Board - Bending strength (MOR) ≈ 17 –23 MPa (Lipski and Karolewski, 2025).

MDF (Compressive) - Compressive strength ≈ 10 MPa (MakeItFrom.com, 2020)

3.3 Design Calculations

3.3.1 Design Load and Stress Calculations for Drawing Table and Stool

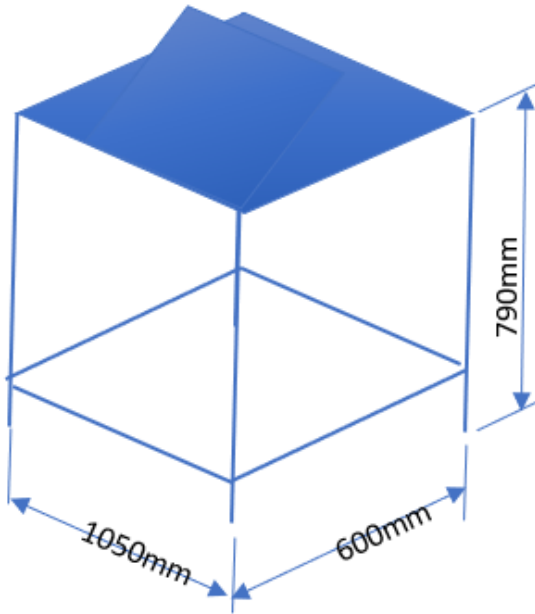


Figure 3.1: Drawing showing key table dimensions

3.3.1.1 Bending moment

Maximum bending moment for uniformly distributed load on simply supported beam

$$M = \frac{w L^2}{8} \quad (3.1)$$

Given table top dimensions as 1050 mm × 600 mm, area in mm² is given by:

$$A = 1050 \times 600 = 630,000 \text{ mm}^2.$$

Converting area to m², we have:

$$jA = 630,000 \times 10^{-6} = 0.63 \text{ m}^2.$$

Uniform pressure on table top is given by:

$$p = \frac{W}{A} \quad (3.2)$$

$$p = \frac{1000N}{0.63} \text{ m}^2 = 1587.301587 \text{ N/m}^2.$$

To get the bending moment, we convert to Line Load

Breadth (long edge) = 1050 mm, i.e. 1.05 m.

Equivalent line load w, = p × breadth:

$$\text{i.e. } p \times 1.05$$

$$= 1587.301587 \times 1.05 = 1666.666667$$

N/m.

$$\text{Short span } L = 600 \text{ mm i.e. } 0.6 \text{ m.}$$

$$L^2 = 0.6^2 = 0.36 \text{ m}^2.$$

Maximum bending moment for uniformly distributed load on simply supported beam

$$M = \frac{w L^2}{8} \quad \text{i.e.} \quad M = \frac{1666.666667 \times 0.36}{8}$$

$$= 75.000000 \text{ N}\cdot\text{m} \quad \text{i.e. } 75000 \text{ N}\cdot\text{mm}$$

3.3.1.2 Section modulus and bending stress for MDF top

Rectangular strip used across the short span (breadth = 1050 mm, thickness h = 20 mm).

Section modulus Z, is given by:

$$M = \frac{b h^2}{6} \times L^2 \quad (3.3)$$

$$M = \frac{b h^2}{6} \times 0.36$$

$$h^2 = 20^2 = 400 \text{ mm}^2$$

$$b \times h^2 = 1050 \times 400$$

$$= 420,000 \text{ mm}^3$$

$$Z = \frac{420.000}{6}$$

$$= 70000 \text{ mm}^3.$$

Bending stress $\sigma = \frac{M}{Z} (\text{N}\cdot\text{mm} / \text{mm}^3 = \text{N}/\text{mm}^2 = \text{MPa}).$ (3.4)

$$\sigma = \frac{75000}{70000} = 1.071429 \text{ MPa}$$

Test for safety of design

Typical MDF bending stress is ≈ 20 MPa. Since the calculated bending stress (1.071429 MPa) << 20 MPa, it implies that the design of the table top with the MDF is safe with a large margin.

3.3.1.3 Leg cross-section and compressive stress

Leg hollow square pipe of outer side b_o = 25 mm; wall thickness t = 2 mm

Thus, inner side b_i is given by,

$$b_i = 25 - 2 \times 2 = 21 \text{ mm.}$$

Cross-sectional area A of leg is given by b_o² - b_i²

$$= 25^2 - 21^2, \text{ i.e. } 625 - 441$$

$$= 184 \text{ mm}^2. \quad \text{or} \quad 184 \times 10^{-6} \text{ m}^2$$

$$= 0.000184 \text{ m}^2.$$

Design total load is given by:

$$W_{\text{design}} = W \times F_s \quad (3.5)$$

$$= 1000 \times 2.5 \text{ (A factor of safety of 2.5 is used)}$$

$$= 2500 \text{ N.}$$

Load per leg P_{leg} is given by:

$$P_{\text{leg}} = \frac{2500}{4}$$

$$= 625 \text{ N}$$

Compressive stress σ_c is given by:

$$\sigma_c = \frac{P_{\text{leg}}}{A_{\text{leg}}} (\text{N}/\text{mm}^2 = \text{MPa}) \quad (3.6)$$

$$\sigma_c = \frac{625}{184}$$

$$= 3.396739 \text{ MPa.}$$

Since the calculated compressive stress ($\sigma_c = 3.396739$ MPa) is much smaller than the allowable stress for the mild steel ($\sigma_y/F_s \approx 100$ MPa), it implies that the design is safe in direct compression.

3.3.1.4 Euler buckling check for table Legs

Second moment of area for square pipe:

$$I = \frac{(b_o^4 - b_i^4)}{12} \quad (3.7)$$

$$b_o^4 = 25^4 \text{ i.e. } 390,625$$

$$b_i^4 = 21^4 \text{ i.e. } 194,481;$$

$$b_o^4 - b_i^4 = 196,144.$$

This implies that,

$$I = \frac{196,144}{12}$$

$$= 16345.333333 \text{ mm}^4.$$

Radius of gyration r is given by:

$$r = \sqrt{\frac{I}{A_{leg}}} \quad (3.8)$$

$$r = \sqrt{\frac{16345.333333}{184}}$$

$$r = 9.425144 \text{ mm.}$$

Leg length $L = 790$ mm.

Euler critical load P_{cr} is given by:

$$P_{cr} = \frac{(\pi^2 EI)}{L^2}, \text{ where } E = 210,000 \text{ N/mm}^2. \quad (3.9)$$

$$P_{cr} = \frac{(\pi^2 \times 210000 \times 16345.333333)}{790^2}$$

$$P_{cr} = 54282.3 \text{ N.}$$

Critical buckling stress σ_{cr} , is given by:

$$\sigma_{cr} = \frac{P_{cr}}{A_{leg}} \text{ (MPa)}$$

$$\sigma_{cr} = \frac{54282.3}{184}$$

$$= 295.013 \text{ MPa.}$$

Since the calculated Euler critical load, P_{cr} of 54282.3 N \gg design leg load 625 N, it implies that buckling is not a concern, and the legs will adequately support the applied load.

3.3.1.5 Detailed calculations for stool

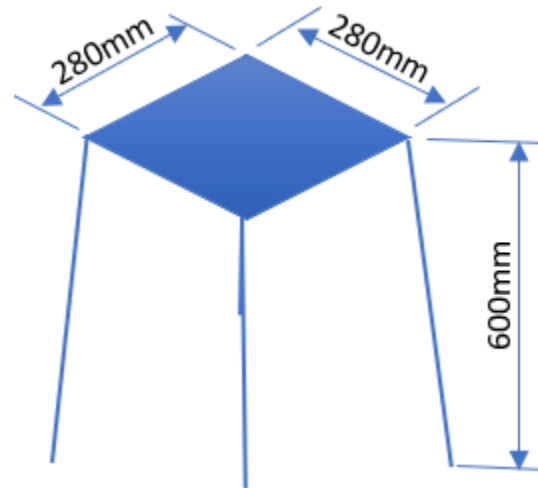


Figure 3.2: Drawing showing key stool dimensions

Stool assumptions: total conservative load

$$W = 1000 \text{ N;}$$

$$\text{Factor of safety, } F_s = 2.5$$

This implies that the design load,

$$W_{design} = 2.5 \times 1000$$

$$W_{design} = 2500$$

Design load for stool. Since stool has four legs,

Design load per leg: P_{leg} is given by:

$$P_{leg} = \frac{2500}{4}$$

$$= 625 \text{ N.}$$

Using same leg cross-section ($A_{leg} = 184 \text{ mm}^2$):

Compressive stress σ_c per leg is given by:

$$\sigma_c = \frac{P_{leg}}{A_{leg}} \text{ (N/mm}^2 \text{ = MPa):}$$

$$\sigma_c = \frac{625}{184}$$

$$= 3.396739 \text{ MPa.}$$

Euler buckling for stool leg ($L = 610$ mm):

Euler critical load P_{crs} is given by:

$$P_{crs} = \frac{(\pi^2 EI)}{L^2}, \text{ where } E = 210,000 \text{ N/mm}^2.$$

$$P_{crs} = \frac{(\pi^2 \times 210000 \times 16345.333333)}{610^2}$$

$$P_{crs} = 91044.4 \text{ N.}$$

Critical buckling stress for stool σ_{crs} , is given by:

$$\sigma_{crs} = \frac{P_{crs}}{A_{leg}} \text{ (MPa)}$$

$$\sigma_{cr} = \frac{91044.4}{184}$$

$$= 494.806 \text{ MPa.}$$

Since the calculated Euler critical load, P_{cr} of 91044.4 N for stool >> design leg load 625N, it implies that buckling is not a concern for the stool, and the legs will adequately support the applied load. Generally, both the drawing table and stool are structurally adequate under the assumed design loading conditions.

3.4 Construction and Installation of the Table and Stool

The process was divided into the following distinct phases: material preparation; measuring, marking out and cutting; welding (tacking) and joining; drilling of openings and fittings; wood finishing and assembly; surface treatment and painting; and finally installation, wherein the completed drawing table and stool sets were taken to the drawing studio, placed there, and joined together in sets with flat metal bars so as to make shifting them individually difficult, and removal of any of them impossible without first using a cutting machine to cut the metal bars. This satisfies the aim of this project work, which is to construct a fixed table and stool set.

IV. TESTS, RESULTS AND DISCUSSION OF RESULTS

4.1 Tests

After the fabrication of the drawing table and stool, functional and load tests were conducted to evaluate their performance and confirm that they met the design requirements. The following tests were performed:

- i. Load Test on Tabletop: Weights equivalent to the estimated design load (approximately 200 N, simulating drawing instruments and user's arm pressure) were uniformly distributed on the 1050 mm × 600 mm MDF tabletop.
- ii. Load Test on Stool: A user weighing approximately 1000 N (\approx 100 kg) was seated on the stool, and the load distribution on the four steel legs was observed.
- iii. Stability Test: Both table and stool were placed on level ground, and lateral forces were applied to check for wobbling, tilting, or loss of balance.
- iv. Surface Test: The tabletop was checked for smoothness and flatness using a straightedge to ensure suitability for drafting purposes.
- v. Ergonomic Test: A seated user was observed while drawing to confirm that table height (790 mm) and

stool height (610 mm) provided comfortable posture and legroom in line with ergonomic standards.

4.2 Test Results

Then results of the tests are as presented in Table 4.1 below:

Table 4.1: Test results

Test Item	Expected Performance	Observed Performance	Remarks
Tabletop load test	Withstand approximately 200 N without deflection failure	No visible deflection or cracking	Passed
Stool load test	Supports 1000 N safely	Stable, no buckling or cracks	Passed
Stability test	No wobbling or tipping	Stable under lateral loading	Passed
Surface flatness	Smooth, level surface	Smooth and flat surface confirmed	Passed
Ergonomic evaluation	Comfortable posture, adequate legroom	Comfortable for user, good posture	Passed

4.3 Analysis of Results

The results show that the fabricated drawing table and stool performed within the design specifications. The table frame, made from 25 × 25 × 2 mm mild steel pipes, demonstrated sufficient stiffness and strength, with no deflection observed under the assumed working load. Similarly, the MDF tabletop of 20 mm thickness remained flat and structurally sound, confirming its suitability for drafting work. The stool frame effectively carried the user's weight, with calculated compressive stresses within the safe limits of mild steel. No instability or deformation was detected during testing, indicating that the applied safety factor was appropriate. The addition of a footrest improved ergonomic comfort, while the fixed seat height matched the table height for correct

drawing posture. Surface finishing also contributed to safety and aesthetics by preventing rusting and eliminating sharp edges. Overall, the tests validated that the design achieved its objectives of strength, functionality, ergonomics, and durability.

V. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The design and fabrication of the drawing table and stool successfully met the functional, ergonomic, and structural requirements for use in academic and workshop environments. By employing mild steel for the frame structures and plywood/MDF for the working surfaces, the design ensured sufficient strength, durability, and cost-effectiveness. The load and stress calculations confirmed that the components can safely withstand anticipated service loads with an adequate factor of safety. Additionally, ergonomic considerations, such as table height, stool design, and provision of a footrest, promote user comfort and proper posture during prolonged use. Surface finishing with anti-rust primer and enamel paint further enhanced durability, aesthetics, and protection against environmental factors.

5.2 Recommendations

- i. Future designs should incorporate adjustable features (like tilting table surface or adjustable stool height) to accommodate users of different anthropometric dimensions.
- ii. Incorporating cushioning or padding on the stool seat may improve user comfort during extended drawing sessions.

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