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Manufacturing Methods and Design Criteria for Simple Mechanical Joints in Rebar Trusses Utilized for RC Beams

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Abstract: This research introduces an analytical design for new simple mechanical joints in hybrid rebar truss reinforcement skeletons. These joints were created to address issues with eccentricity and truss diagonal cold bending commonly seen in the traditional hybrid rebar truss joints. These issues can lead to complex stresses and potential premature failure, particularly during the initial construction phase when the nude rebar truss skeleton must support its own weight, precast slabs, and fresh concrete loads before composite action is achieved. A detailed analytical framework based on design principles is presented, including verification guidelines and formulas for calculating joint capacities under various forces. This proposed method enhances load distribution stability and ensures the reliability of the truss structure until composite action with concrete is fully established.

1. INTRODUCTION:

This research presents a new design for simple mechanical joints in rebar truss reinforcement skeletons used in concrete beams. These joints aim to address issues related to eccentricity and structural weaknesses often seen in bent and welded truss diagonals at the joints in traditional rebar trusses. These drawbacks can result in complex stresses and premature failure, especially during the construction phase I when the rebar truss skeleton must support its own weight, precast slabs, and fresh concrete loads before achieving composite action in the concrete beam. A combination of rebar trusses and concrete beams offers a structural solution where the truss skeleton works with the cast-in-situ concrete in a dual-phase mechanism. Unlike traditional reinforcement detailing, the truss in these systems carries loads and supports weight independently until the concrete cures and contributes to composite behavior. The origin of this traditional rebar truss system is often credited to Salvatore Leone in Italy, who patented the concept in 1967, 1974 and 1976, and developed early production rules for industrial applications. Phase I of construction is vital for safety as the truss skeleton must bear loads temporarily without the hardened concrete's support. Traditionally, truss skeletons are made by bending and welding diagonals to upper and lower chords, leading to topological flaws and misalignment of load paths which can result in complex stresses, premature yielding, weld node cracking, brittle joint failures, and ultimately the collapse of the entire truss structure. In 2009, Tesser concluded that using traditional rebar truss skeletons caused truss joints on the top chord to rotate and bent bars in upper joints to break. This is related to that the joints are the weakest points, especially in phase I, so recent studies have been looking at replacing the welding and bending of the joints with simple mechanical joints to fix issues with uneven force transmission and eccentricity defects. Also, Silva et al. (2020), López et al. (2023), Lee, H. (2023), Vital et al. (2024), and Barcewicz et al. (2025) observed that misalignment resulting from the eccentricity of truss joints, caused by joint defects, can lead to localized failure and eventual collapse of the entire truss system. Ahmed Y. Al-Tuhami et al. (2025) proposed simplified mechanical truss joints of Type A and Type B and conducted comprehensive experimental tests, the results showed that enhancement the performances during the phases I and II. The incorporation of mechanical joints also led to a more evenly distributed stress pattern, minimizing the risk of joint failure, and mitigated premature collapse in the early stages of construction. This particular study holds significance as it offers a clear delineation of performance metrics across two phases and establishes a direct correlation between joint characteristics and the structural integrity during the initial phases as well as the seamless transition to composite beams. While the substitution of mechanical joints for bending and welding in truss rebar diagonals coupling is a new and influential factor in the truss structure as a whole, there is still a practical gap in many design and manufacturing contexts: connection details are often treated as a “structural detail” rather than an essential design element with explicit strength checks. This can be problematic because, for hybrid rebar truss concrete beams, premature failure often initiates at the joint where tension and shear demands concentrate. Accordingly, this study focuses on producing design-oriented rules and equations to verify the mechanical truss joint capacities under axial tension, compression and shear, with the explicit goal of preventing early joint failure particularly in phase I. The proposed methodology aims to (1) define the maximum tensile capacity of the joint to keep the joint safe against the weakest point,

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(2) provide shear verification aligned with the expected force path through the joints, and (3) support a more centered, predictable transfer mechanism that reduces the adverse effect of eccentricity and exerted moments at the truss joints. In doing so, the work seeks to present the accumulated insight from prior research into a concise, implementable set of checks that improve reliability during construction and ensure a safer transition to final composite behavior of the trussed beam.

2. PREPARATION OF THE PROPOSED MECHANICAL JOINTS AND TRUSS SKELETONS:

The research project opted for hot forging as the method of choice in producing nodes with perforations for connecting truss diagonals to upper and lower chords. Hot forging was selected due to its convenience, efficiency, and precision in molding materials. Furthermore, unlike cold forging, the rebar steel alloy does not undergo hardening during the hot forging process, thus mitigating potential hardening problems via recrystallization. This investigation involved the utilization of two distinct shapes for truss joints, denoted as A and B. These two varieties of joints, A and B, offer the advantage of having the longitudinal axes of the upper and lower chords intersect with the longitudinal axes of the diagonals at the centers of the truss joints, thereby embodying the foundational principles of a real truss structure. The initial phase of each truss fabrication process entails cutting the reinforcing bars to specific lengths corresponding to the upper chord, lower chord, and diagonals. Certain segments of these rebars are then modified through the hot forging procedure, resulting in nodes with perforations in each component of the truss. In order to manufacture nodes at the ends of the diagonals and in the upper chords, it is necessary to enlarge the dimensions of these locations during the initial stages prior to flattening them and creating hole in the center, thus ensuring that the cross-sectional area at any point in these nodes along the longitudinal axis of the reinforcing bar is not less than the cross-sectional area of the reinforcing bars.

2.1 The proposed truss skeleton with mechanical joints type A:

The truss skeleton's beam reinforcement utilizing joint type A involves two laminar diagonal webs linked to a 5 mm thick bottom steel plate, while the diagonal web bars are connected to the upper chord bars via mechanical joints of type A. Both the diagonal webs and upper chord components are made of rebar matching grade and diameter. To connect the upper chords to the truss diagonals through mechanical joints, tubular sleeves and steel pieces are utilized. Each sleeve features serrations on its inner surface to increase friction between the sleeve and the rebar upper chord. The inner diameter of the joint sleeve is slightly larger than the upper chord's diameter, including the rebar circumferential rib thicknesses, to facilitate easy insertion. Three holes were drilled to accommodate M10 bolts, grade 12.9, to connect the upper chord to the mechanical joint's sleeve. A plate piece, measuring 10 mm in thickness and 85 mm in length, along with one or two 20 mm holes corresponding to the rebar diagonal end holes, extends out from the sleeve portion's outer surface parallel to the truss's longitudinal axis. This mechanical truss joint is repeated at regular intervals equal to 400 mm on the upper chord. Bolts (M20 grade 8.8) are used to secure the diagonals to the plate pieces. Similar plate pieces with a thickness of 10 mm and a length of 85 mm, along with one or two corresponding holes for the rebar diagonal, are welded to the bottom steel plate (the lower chord). The mechanical joint, which connects the lower chord with diagonal webs by steel strips with a thickness of 10 mm, has two holes executed in the lower mechanical joints with a diameter of 20 mm, which connect the lower steel plate with the diagonal web. For each upper and lower mechanical joint, the value of eccentricity due to internal forces is zero in members at joints. Figure 1 shows the detail of upper mechanical joint type A, and Figure 2 shows the upper and lower mechanical joints in the truss.

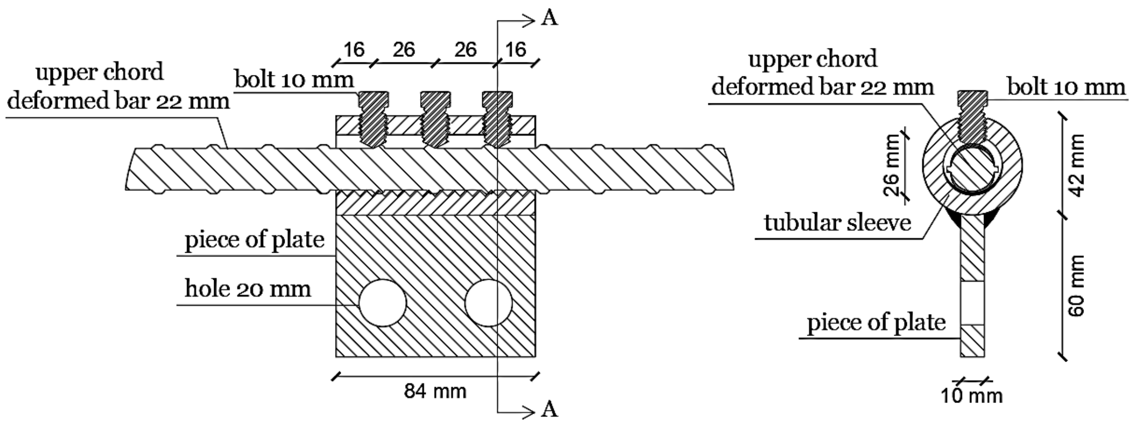

Figure 1: Details of mechanical joint type A.

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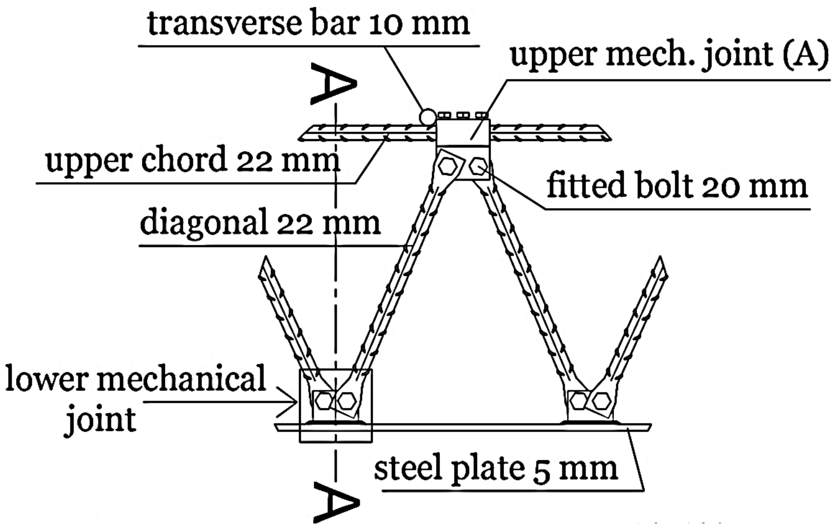

Figure 2: the upper and lower mechanical joint in truss skeleton.

Each laminar truss skeleton featured an upper chord comprised of a singular 22 mm diameter deformed steel bar. The top chord did not undergo any shaping processes, while the nodes located at the ends of the diagonals were formed through hot forging, as outlined earlier. The process involved in forming the shape included heating both ends of the diagonal to approximately 700 degree. Once heated, the diagonal ends are then struck to transform the shape into a circular shape, as illustrated in Figure 3.

Figure 3: Forging process for diagonal bars.

The assembly process of the truss skeleton using mechanical joints of type A commenced with the preparation of the lower steel plate, which represents the lower chord to the specified dimensions, followed by placement on a level surface. Steel strips, each with two holes, were affixed to the lower steel plate. The spacing between each mechanical joint was set at 400 mm. Diagonal bars had one end's node secured to the steel strips using 20 mm fit bolts, while the other end was attached to the upper mechanical joint by bolting it to a steel piece connected to one sleeve piece according to the truss design. Each rebar for the upper chord was inserted through the sleeve pieces in the upper mechanical joint's sleeves. Three 10 mm bolts passed through threaded holes along the longitudinal axis of the sleeve piece to secure the upper chord in the upper mechanical joints, followed by the injection of epoxy grout to enhance the bonding. A rebar with a diameter of 22 mm was used to brace the upper chord of a laminar truss with the lower chord of the adjacent laminar truss, preventing lateral movement. These vertical braces were placed at two supports and load points, while upper horizontal bars with a diameter of 10 mm were welded between the sleeves of the laminar trusses to improve stability and rigidity and prevent lateral buckling. In the case of a truss skeleton, make a triangle shape in the lateral direction. There is no need for bracing between the two laminar trusses because the possibility of buckling is excluded because the forces acting on the upper chord at the joints are dispersed in two directions, and the force causing the buckling is very small.

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2.2 The proposed truss skeleton with mechanical joints type B:

The truss type B forming process begins with cutting the reinforcing bars with specified lengths representing an upper chord and diagonals. Certain sections of these rebars are shaped through the process of hot forging, resulting in nodes with a hole (eye node) in each individual member. Manufacturing nodes in the upper chord and in the ends of the diagonals requires enlarging the size of the locations of those nodes in their initial stage, then flattening them and forming the hole in the middle of their nodes so that the cross-sectional area at any section in these nodes along the longitudinal axis of the reinforcing bar is not less than the cross-sectional area of the reinforcing bars. The lower chord is a steel plate. The pieces of plates that connect the diagonal with the lower chord are prepared with one or two holes corresponding to the holes shaped in the diagonal bars to be assembled. These pre-holed plate pieces serve as bolting points for the diagonal bars and the lower chord (steel plate). These pre-holed plates are welded to predetermined places along the length of the bottom plate (lower chord) according to the truss design. The diagonal bars are then assembled with the upper chords and the lower chord (steel plate) to form the final shape of the truss. The elements of the truss skeleton are the same elements for the specimens, which include mechanical joint type A for grade, diameter, or thickness for the upper chord, diagonal bars, lower chord, and lower mechanical joint. The exception for the mechanical joint type A is replaced by another very simple joint. A new feature of the new joint is the perforation of the upper chord rebars by forging processes. One point is heated at a temperature of approximately 700 degrees Celsius every 40 cm of the rebar, depending on the carbon content of the steel material. The area being heated is then shaped into a circle by knocking it, as depicted in Figure 4. Following the preparation of the upper chord rebars, diagonal rebars are also created through the forging process. Figure 5 displays the specifics of the upper mechanical joint type B.

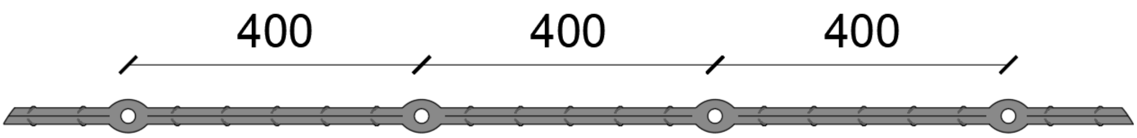

Figure 4: Shape of upper chord after forging and perforation.

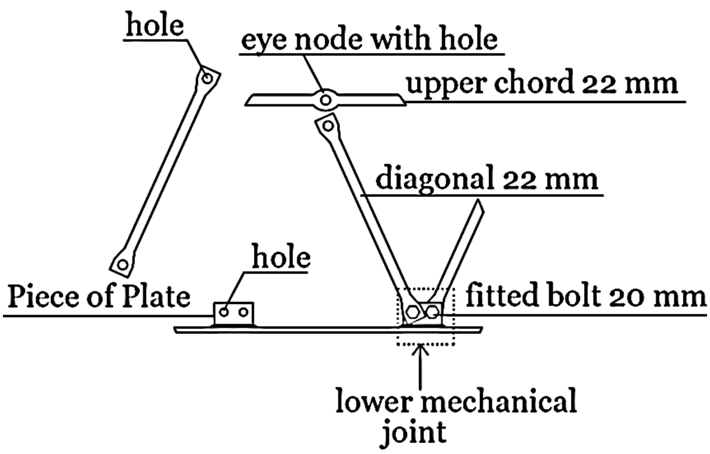

Figure 5: Upper and lower mechanical joint in truss skeleton.

3. REBAR MATERIAL:

The reinforcing bars used to produce the truss specimens were 22 mm. The tested yield and ultimate strengths were reported as 525 and 720 MPa, and the elongation percentage was 13.2%. Figure 6 shows the stress-strain graph for deformed steel rebar. The primary reason for selecting high-grade steel for the upper chord of hybrid truss concrete beams was because during phase I, only the upper chord experiences significant compressive forces before the concrete is poured into the beam reinforcement skeleton system. This is due to the weight of precast slabs, fresh concrete, and construction work loads being transferred through the truss, and it shows the vertical bracing to resist out-of-plane buckling.

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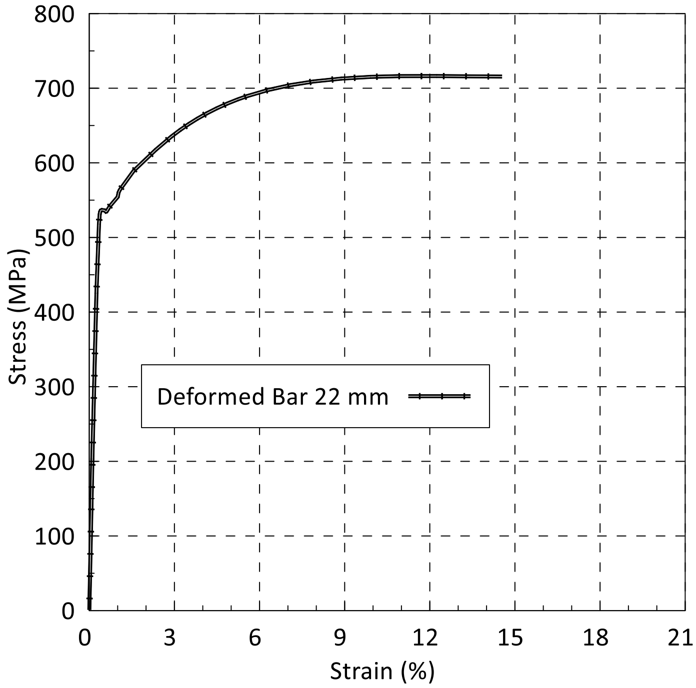

Figure. 6: Stress vs. strain graph for deformed steel rebar.

3. Design of mechanical joints of type A and B:

When designing the steel truss structural joints, the mechanical joint configurations from the preceding section can be categorized into three distinct types. Types A and B are situated at the upper chord, while Type C is situated at the lower chord. For type A, the coupler sleeve enclosing the reinforcing bar experiences compressive and tensile forces depending on the position of the beam (simple or continuous). The welded steel strip, equipped with two holes for joining the diagonal webs to the upper chord, bears axial stresses; however, axial stresses are converted to shear in the steel strip and the connecting fitted bolts. The behavior of a welded steel strip to a sleeve at the upper chord is comparable to that of the steel strip that welded to bottom steel plate (lower mechanical joints type C). For type A, this joint differs from the previous configuration as it uses an eye-bar, which primarily resists axial tension or compression stress in the top chord. The axial stresses transmitted from the web members are significantly reduced at this joint due to a concentric (non-eccentric) load path, which minimizes secondary moments and results in a predominantly axial force transfer.

3.1. Mechanical joints type B and C

In AISC 316-16, the mandatory detailing and geometric requirements for an eye bar to be checked before calculating tension, shear, or bearing capacities are given in the AISC 360-16, where eye bars must have consistent thickness and round heads that are concentric with the pinhole. The transition from the round head to the body of the rebar must have a radius that is equal to or greater than the diameter of the head. The diameter of the pin must be at least seven-eighths times the width of the eye bar body, and the diameter of the pinhole should not exceed 1 mm more than the pin diameter. The hole's diameter must not surpass five times the thickness of the shaped bar, and the eye bar body's width should be adjusted accordingly. The distance from the edge of the hole to the edge of the shaped bar, in a direction perpendicular to the applied load, must exceed two-thirds and not exceed three-fourths of the width of the eye bar body for calculation purposes. From reber of 22 mm, the eye bar dimensions can be computed by the following specification and shown in Figure 7.

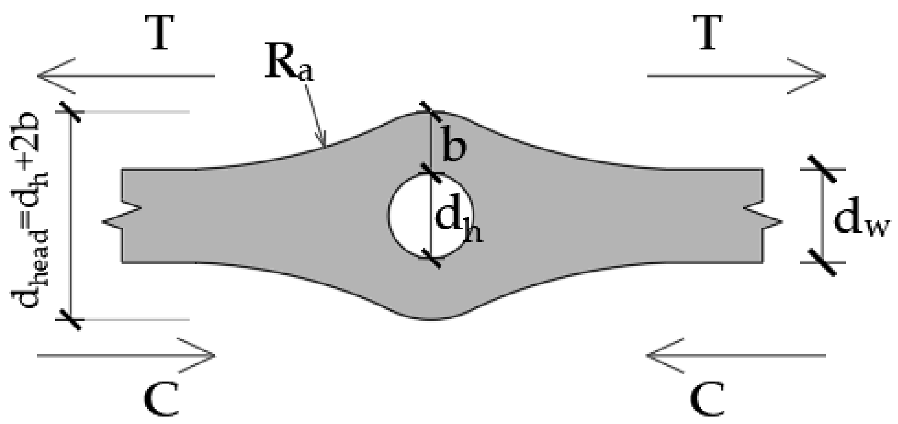

Figure 7: Eye bar configuration.

1- Diameter of the fitted bolts $\leq \frac{7}{8} d_w$
2- Thickness of the shaped bar (T_s) is 15 mm.
3- $d_h \leq 5T_s$, 5x15=60mm, d_h =20 mm < 60 mm.
4- R_a= 125 mm > $d_{head} = d_h + 2b = 20 + 30 = 50\ mm.$
5- $\frac{2}{3} d_w \leq b \leq \frac{3}{4} d_w, b = \frac{2}{3} d_w = \frac{2}{3} x22 = 14.6mm.$

The design of an eye-bar is controlled by its geometry and physical dimensions, in addition to the applicable strength limit states. In strength design, the governing limit state is taken as the minimum capacity among the following modes: tensile rupture, shear rupture, bearing on the member, and yielding, as summarized below:

1- Tension is taken as acting on the entire effective area of the eye-bar head (eye region).

$$T = 2btf_u \quad (1)$$

2- A shear effect may develop in the eye-bar located in the top chord of the structural truss due to the forces transferred from the web members, whether in tension or compression, as shown in Figure 8. However, the adopted mechanical joint assumes a concentric connection with no geometric eccentricity, while the load path passes through the fitted bolt centerline. Therefore, the shear resultant is expected to be theoretically limited. Nevertheless, the actual shear effect may occur as primarily fabrication, processing, and erection imperfections. These may include, for example, hole diameter and tolerance variations, lack of flatness of the eye surface, misalignment between the pin and the connection axes, or inadequate finishing of the hole edges. Accordingly, a shear check on the effective area is performed as a conservative verification to ensure that no undesirable local stresses or deformations develop around the eye and pin region, even in the presence of minor execution deviations.

$$Q_{sf} = 0.6\ tf_u A_{sf} \quad (2)$$

With respect to bearing in the pin–eyebar connection, it may develop due to the force transfer mechanism within the truss. The top chord can be subjected to either tension or compression depending on the loading case and force distribution. In cases where the top chord experiences compression at midspan, localized contact pressure may arise as the pin bears against the wall of the eye-bar hole, resulting in bearing stresses in the eye region.

A similar bearing mechanism may also occur in the inclined web-member eye-bars connected to the same pin at the top chord, since the tension or compression forces in these members are transmitted through the pin and are likewise converted into local bearing pressure at the hole surface. Accordingly, the connection is checked in accordance with AISC 360-16, where the local limit states at the hole are verified, including bearing strength at the hole and the bearing strength can be computed by the following formula:

$$f_b = 1.8\ f_u btd_{bolt} \quad (3)$$

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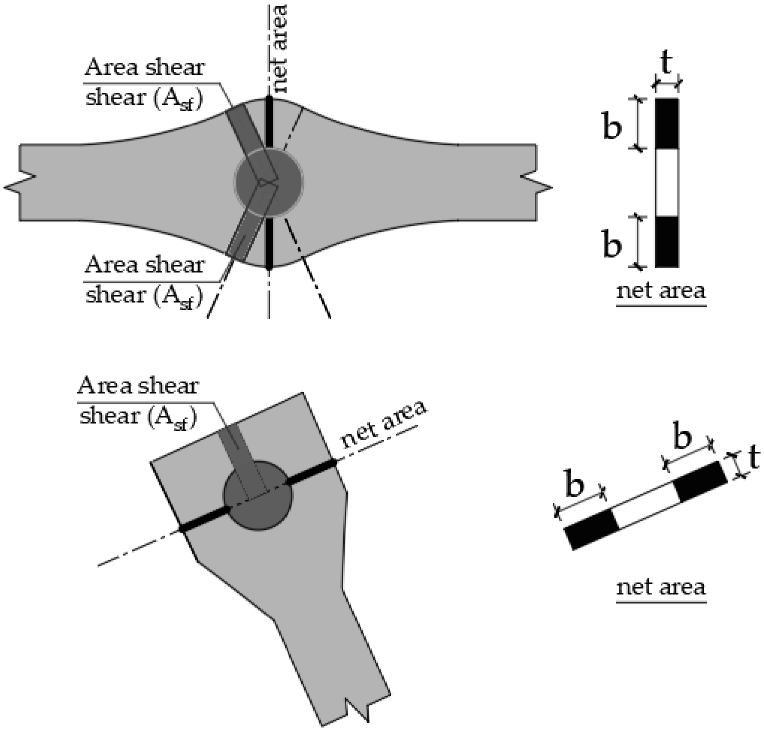

Figure 8: Net tensile and shear area affects the eye bar.

3.2. Mechanical joints type A

The proposed mechanical coupling can employ several connection techniques. One such technique is a shear-screw coupling to connect the longitudinal reinforcing bar of the truss' upper chord which prevent any relative slippage. The coupling is welded at its base to a steel strip containing two holes for securing the diagonal web members.

Depending on the truss' service stage, the upper chord may be subjected to compressive stresses under certain loading conditions. Therefore, the connection must be designed to transfer these stresses without causing slippage of the reinforcing bar within the coupling. In this type of connection, slippage is resisted through two main mechanisms: The friction generated by the bar's contact with the internal thread of the sleeve. The compression force resulting from the wrench torque of the shear screws, which increases the vertical pressure on the bar's surface, therefore increasing friction and limiting relative slippage. The actual performance and slip resistance of a shear-screw sleeve depend on several interrelated factors, the most important of which are: the bolt grade, which allow for greater wrench torque and higher compressive force, and the bolt diameter, which affects the torque and force generated. Sleeving material is also a crucial factor to prevent internal threads from deteriorating or "softening" over time, which can lead to a decrease in slip resistance. Additionally, the sleeve length, the number of bolts, and their distribution around the perimeter all directly affect the total available holding force and the stability of the rebar within the joint. Although truss behavior is typically characterized by a significant decrease in stress values at joints compared to inter-node areas, the upper chord bar here is continuous along the chord and not cut at the joint. Therefore, the dominant force on the joint is not measured by the nominal compressive stress of the chord as a whole, but rather by the difference in axial forces across the joint, which means the force value is the difference between the chord force before and after the joint. This difference can be adopted as a design value for the mechanical joint, and it is often a small difference, which may allow for a more economical solution while maintaining structural requirements. Figure 9 shows the contact pressure distribution and force flow in the selected coupler system. The welded steel strip beneath the coupling serves to connect the web members, and its behavior is similar to that of an eye bar. Therefore, it can be evaluated for tension, shear, and bearing using a similar approach to evaluating eye bar connections, consistent with the local failure mechanisms discussed previously in the design of hole zones.

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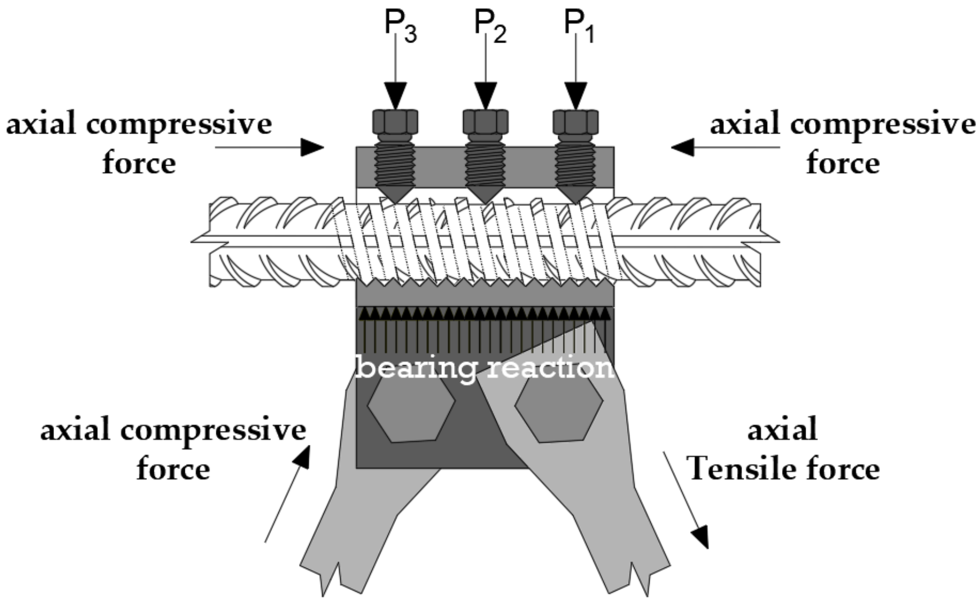

Figure 9: Contact pressure distribution and force flow in the selected coupler system.

Regarding the design of the proposed mechanical joint to resist the slippage of reinforcing bars within the lower chord of the truss, a design approach was adopted that combines a mechanical understanding of the slippage resistance mechanism with guidance from published experimental results, rather than depending only on abstract theoretical calculations of frictional resistance. Accordingly, the experimental study by Al-Tuhami et al. (2024) was used, in which the performance of three sets of shear-screw couplers was evaluated, along with the effect of several design and operational variables that directly control slippage resistance and the coupler's behavior under load.

In this study, the sleeves were fabricated from 42CrMo steel due to its good resistance to wear and surface fracture, and its suitable ability to withstand localized stresses resulting from shear screws. Meanwhile, screws of grade 12.9 were used to ensure high compressive forces during coupling and improve fastening efficiency when torque is applied. The choice of sleeve material is crucial in this type of connection, as the sleeve acts as the medium through which forces are transferred between the bolt and the rebar. Any deterioration of its internal surface such as thread smoothing can lead to a gradual decrease in slip resistance during service.

The specimens in this study were divided into three degrees of dependence on friction versus mechanical engagement at the contact surface between the rebar and the sleeve, as follows:

Group 1 (one sample): The rebar protrusions were not threaded. Therefore, the slip resistance was primarily due to the clamping force generated by the bolt pressing against the rebar. This force increases the perpendicular pressure at the contact surface between the rebar and the sleeve, thus increasing slip resistance through friction. This group can be considered representative of a case of “near-complete dependence on friction” with no clear engagement between the rebar protrusions and the sleeve surface.

The second group involved partial threading of both a portion of the threading body and a portion of the reinforcing bar deformations. This was done to increase resistance by combining friction and partial mechanical interlock. This reduces reliance on bolt pressure alone, improving the mechanical bond between the two surfaces and thus increasing slip resistance and enhancing joint stability under repeated loading.

The third group involved full threading of both the bar deformations and the threading. This maximizes mechanical interlocking compared to the previous two groups, resulting in the highest slip and shear resistance in the contact area. This group also incorporated a greater number of operational and design variables, allowing for a more comprehensive evaluation of each variable's impact on joint performance.

As shown in Table 1 of the study, the impact of several key variables controlling slip resistance was examined. These included the number of bolts used in the coupling, the number and distribution of bolt rows, the applied torque values during connection, bolt diameters, and the effective length of the joint. In the current application, it should be noted that the joint does not function as a splice between two rebars, but rather as a fixing and securing mechanism for a single rebar within the sleeve. The joint is then welded to a steel plate to create a mechanical connection point that allows the inclined web members to be attached to the lower chord. Therefore, the joint length was treated as half the functional length of the joint, since the primary objective here is to secure the rebar within the sleeve, not to achieve a coupling of two-rebar.

Table 1 shows that the joint in the first group, where the rebar was not threaded had and a sleeve length of approximately 130 mm and the diameter of bolts of 16 mm as reference values under the test conditions. The results clearly indicate that increasing the

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degree of contact between the sleeve body and the rebar (whether through partial or full threading) leads to a significant improvement in slip resistance, while simultaneously allowing for smaller joints with higher load-capacities. Therefore, the values in the table can be considered a practical reference for determining the initial dimensions of the proposed mechanical joint such as bushing length, diameter, number of bolts, and tightening torque. These dimensions are then adjusted to match the actual design forces acting on the joint in this study.

The truss systems are typically characterized by uniform axial forces away from nodes, and forces at connection points are often lower, the actual force acting on the mechanical joint can be more realistically estimated by considering the difference in axial forces across the joint area (before and after the joint) rather than assume.

Shear Friction	Half-length of sleeve	External diameter of sleeve	Shear screw diam.	No. of bolts	No bolts rows	Yield stress	Ultimate Strength
No thread of bar, thread on sleeve.	130	58	16	8	1	405	573
Full thread of bar and sleeve.	62.5	50	10	8	2	511.1	695.9
	62.5	50	12	8	2	521.8	714.7
Partial thread of bar and sleeve	110	55	12	8	1-3	527	700.1
	85	55	12	10	2	497	629
	67.5	55	12	8	2	548	685.3

Table 1: Dimensional details, Yield stress, ultimate strength of tested specimens.

Design considerations

In Figure 10, sectional elevation and cross-section of two ends of the reinforcing bars (a and b) are axially aligned with the two coupler halves. When the Reinforcing bars are subjected to tensile forces Q, the resulting forces in the reinforcing bar deformation P_n divided into S_n and N_n where:

$\boldsymbol{Q}$ = ultimate tensile load for bar.
$\boldsymbol{P_n}$ = reaction force on the bar deformation.
$\boldsymbol{S_n}$ = separation force on one halve of the two splits.
$\boldsymbol{N_n}$ = the vertical force on the bar and sleeve deformation.
$\boldsymbol{Z}$ = No. of deformation in one halve of split for bar (a).
$\boldsymbol{F_n}$ = confining force.

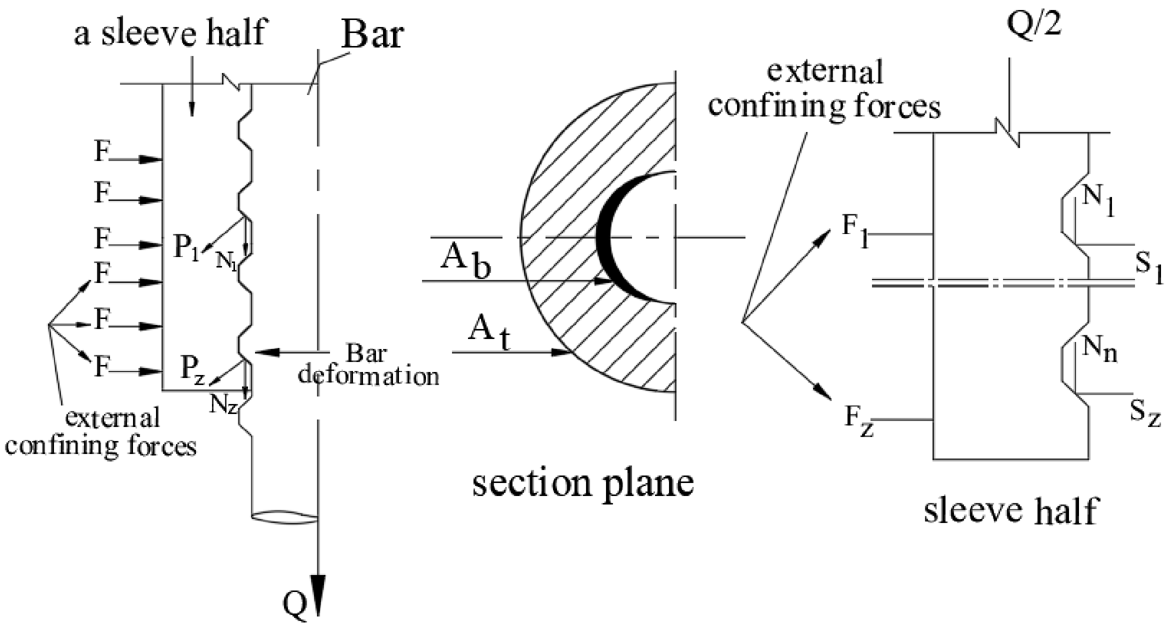

Figure 10: Two ends of the reinforcing bars subjected to axial force Q.

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Design due to bearing pressure:

The maximum bearing pressure on the deformation can be calculated by the following equation:

$$\sigma_b = \frac{N_{max}}{A_b} \tag{4}$$

Where:
A_b : the horizontal projection area of one thread or deformation based on shear type resistance.
σ_b : the safe bearing stress for bar and sleeve material.

Design due to shear stress:

The maximum direct shear stress on the deformation can be calculated by the following equation:

$$\tau_s = \frac{N_{max}}{A_s} \tag{5}$$

Where:
A_s: the shear area of one deformation (the development area).
τ_s: the safe shear stress for bar material.

Design due to tension stress:

The maximum tensile stress on the sleeve half can be calculated by the following equation:

$$\boldsymbol{\sigma_t = \frac{Q/2}{A_t}} \tag{6}$$

Where:

A_t: the net cross-section area of one halve of the sleeve.

$\boldsymbol{\sigma_t}$: the safe tensile stress for split material.

Confining force:

The confining forces results from closure systems must be greater than the summation of the separation forces as follows:

$$\sum_{n=1}^{n=z} F_n \succ \sum_{n=1}^{n=z} S_n \tag{7}$$

and

$$\frac{Q}{2} = \sum_{n=1}^{n=z} N_n \tag{8}$$

CONCLUSION:

The following points summarize the most important findings of the study regarding the manufacture and design of the proposed mechanical joints and the assembling of truss members:

1- A practical manufacturing method is described in this research to create two new mechanical joints for rebar trusses. These joints were developed to overcome challenges associated with traditional joints that involve welding and bending of the truss diagonals.
2- The research outlines straightforward instructions for constructing mechanical joints of type A and B.
3- Suggested formulas have been proposed for designing mechanical joints type A and B, enabling the precise prediction of their dimensions.

REFERENCES

[1] Al-Tuhami, A. Y., Ghallab, A., & Al-Tuhami, A. T. A. (2025). Effect of utilizing simple mechanical truss joints on the performance of hybrid truss-concrete beams subjected to bending. In Structures (Vol. 78, p. 109224). Elsevier.
[2] Al-Tuhami, A. T. A., Al-Tuhami, A. Y., & Ali-Eldin, S. S. (2024). The modified shear screw couplers, development, and an experimental investigation. Engineering Structures, 319, 118726.
[3] American Institute of Steel Construction. (2016). Specification for Structural Steel Buildings (ANSI/AISC 360-16). American Institute of Steel Construction.
[4] Barcewicz, W., Wierzbicki, S., Giżejowski, M. A., & Labocha, S. (2025). Experimental tests of tension connections of steel angle sections of lattice transmission towers. Archives of Civil Engineering, 71(1).
[5] Leone S. (1967), REP® beam calculation methods. Deposited at the Italian Superior Council of Public Works.
[6] Leone S. (1974), Metal trestle for manufacturing reinforced-concrete beams for floors. U.S. Patent No., 3. Washington, DC: U.S. Patent and Trademark Office; p. 505.
[7] Leone S. (1976), Metal U-channel shaped element for reinforcing floors of concrete and lightening filling blocks. U.S. Patent No., 3. Washington, DC: U.S. Patent and Trademark Office; p. 954.
[8] Lee, H. (2023). Evaluation of Gusset Plate Buckling, Member Eccentricity Effect, and Pin Strength for Steel Truss Bridges (Doctoral dissertation, University of California, San Diego).
[9] López, S., Makoond, N., Sánchez-Rodríguez, A., Adam, J. M., & Riveiro, B. (2023). Initiation and propagation of failures in steel truss bridges. ce/papers, 6(5), 377-380.
[10] Silva, W. V., Silva, R., Bezerra, L. M., Freitas, C. A., & Bonilla, J. (2020). Experimental analysis of space trusses using spacers of concrete with steel fiber and sisal fiber. Materials, 13(10), 2305.
[11] Tesser, L. (2009). Composite steel truss and concrete beams and beam-column joints for seismic resistant frames: modelling, numerical analysis and experimental verifications. (Doctoral dissertation).
[12] Vital, W., Silva, R., Bezerra, L. M., Oliveira, C. M., Freitas, C. A., & Bonilla, J. (2024). Experimental and Numerical Analysis for Eccentricity Solution in Double-Layer Space Truss. Buildings, 14(3), 608.