DESIGN OF GRIPPER IN UNIVERSAL TESTING MACHINE

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ABSTRACT

Universal Testing Machine (UTM) has fixtures for holding the test specimen called gripper in which the both ends of the test specimen fitted. When there is change in the design of gripper, it is possible to increase the gripping force due to which there is increase in the holding capacity of gripper. Gripper design affected by various parameters like Rebar diameter, Allowable tensile stress, Maximum permissible tensile stress, Maximum load carrying capacity, Reaction forces on wedges and gripping force..

Keyword: - *Universal Testing Machine, Mechanical wedge, Rebar, Gripping force, Mathematical analysis.*

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1. INTRODUCTION

Introduction Universal Testing Machine (UTM) is used to test the tensile stress and compressive strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures.[1]

Tensile Test: Clamp a single piece of anything on each of its ends and pull it apart until it breaks. This measures how strong it is (tensile strength) how stretchy it is (elongation), and how stiff it is (tensile modulus).

Compression Test: The exact opposite of a tensile test. This is where you compress an object between two level plates until a certain load or distance has been reached or the product breaks. The typical measurements are the maximum force sustained before breakage (compressive force), or load at displacement, or displacement at load.

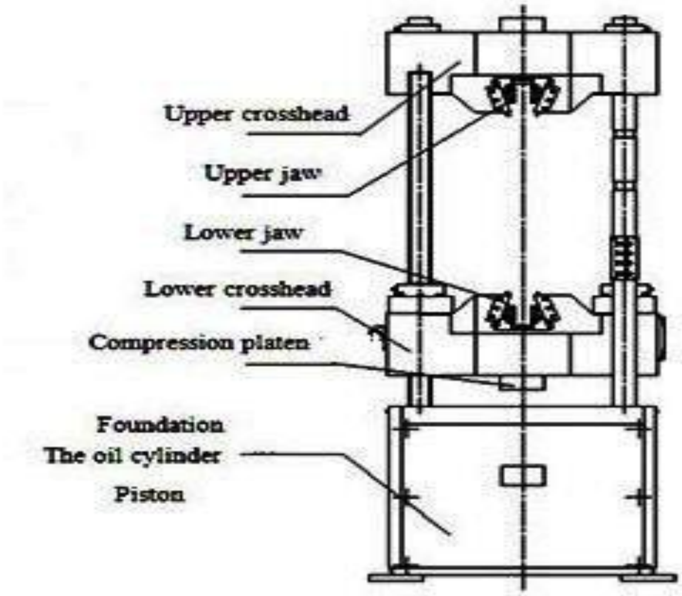


Figure 1: Universal Testing Machine [2]

Our focus is on design of gripper in UTM. For research work chosen Tension testing machine 500 KN capacity model

Figure 2: Tension testing machine 500 KN capacity model 70-C0019

Sr No.		
1	Load capacity in tension(KN)	500
2	Maximum vertical clearance(mm)	330
3	Maximum distance between grips(mm)	220
4	Distance between columns(mm)	310
5	Overall dimensions approx. (mm)	1820x740x420
6	Approximate weight(kg)	535

Table 1: Specifications of UTM

SPECIFICTIONS OF UTM: [3-8]

(a)UNIVERSAL TESTING MACHINE:

EN –ISO 7500-1, ASTM A370, EN 15630-1

(b)Rebars:

ASTM A615/A615M: Deformed and plain carbon-steel bars for concrete reinforcement

(c) Gripper: [9]

AISI 1040/45 Specifications: BS EN8

2. GRIPPER CONSTRUCTION[6]

Gripper contains number of parts as shown in figure below

Figure 3: Parts of Gripper housing

Figure 4: Gripper with Assembly parts

Figure 5: Detail of frame 70-C0019 with Grip holders mounted and sample inserted [6]

3. GRIPPER DESIGN

Gripping principle:

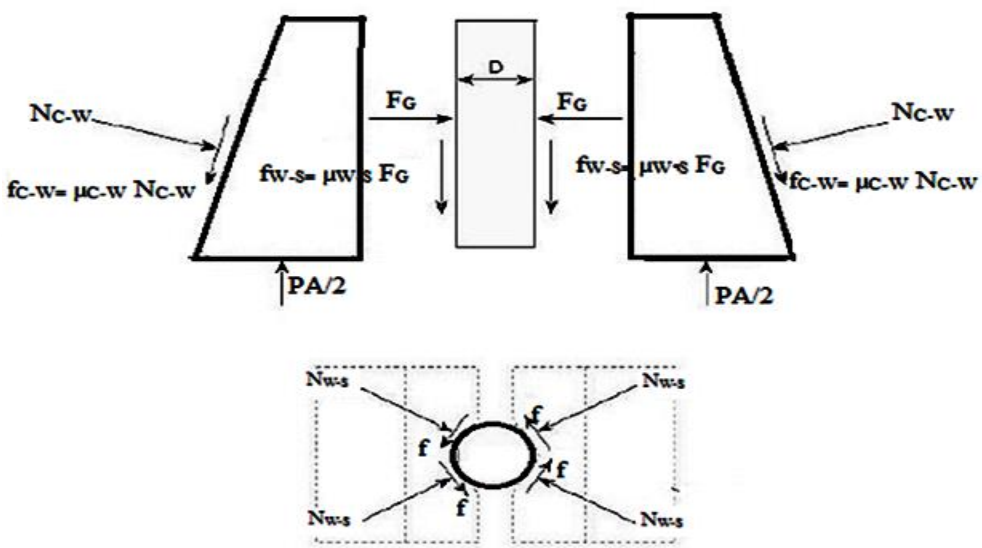


Figure 6: Gripping principle

<u>Nomenclature:</u>

D=Diameter of round specimen

$F_{G=}$Gripping force of the wedge specimen

L = Maximum axial load applied to the specimen

N_{C-W} =Normal forces between the grip chamber and wedges

N_{W-S} = Normal forces between the wedge and specimen

P = Grip supply pressure

μ_{C-W} =Static co-efficient of friction between grip chamber and wedge

μ_{W-S} = Static co-efficient of friction between wedge and the specimen

Resolving components in horizontal and vertical direction:

$$R_N = \frac{PA}{2} Sin\alpha + F_G Cos\,\alpha \quad \dots (1)$$

$$\frac{PA}{2} Cos\,\alpha = F_G Sin\alpha + F \quad \dots (2)$$

Gripping Force,

$$F_G = \frac{PA}{2} \frac{[Cos\alpha - \mu\, Sin\alpha]}{[Sin\alpha + \mu\, Cos\alpha]} \quad \dots (3)$$

With the help of this equation gripping force exert in existing gripper is about 212 KN

DESIGN OF THE WEDGES: [12]

For testing in tension, the principle of a wedge is used. Therefore, the more the specimen is pulled, the higher the contact pressure becomes and the better the specimen is gripped.

Initially the setup in below Figure 7, Part A which is considered as a block. Its function is to deliver a certain downward force on the two grips. A force of 2F is applied, so that each grip is loaded with F.

In this analysis, the assumption is made that the clamps will first be loaded in tension and then in compression. This assumption is justified by the fact that a normal tension– compression test starts in tension. This however has an important influence on the calculation since the loading in tension will put a certain prestress on the wedges that will have an effect when loading in compression afterwards.

In Figure of force equilibrium condition on the inserts for case of tensile situation as shown in Figure 7(a) and Figure 7(b), one grip is illustrated, with all forces that need to be taken into account. The direction of the friction forces T_A and T_B is chosen according the way they work.

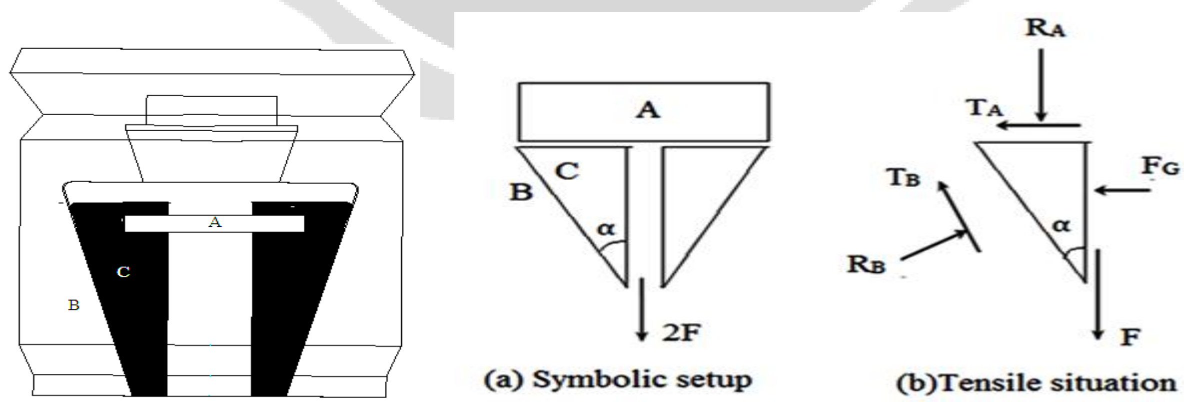


Figure 7: Force equilibrium on the inserts

For the tensile situation, the equilibrium of the grip combined with the friction leads to the following equation:

$$F+R_A = R_B \sin\alpha + T_B \cos\alpha \quad \text{... (4)}$$

$$F_G+T_A+T_B \sin\alpha = R_B \cos\alpha \quad \text{... (5)}$$

$$T_A \leq \mu_{AC} R_A \quad \text{... (6)}$$

$$T_B \leq \mu_{BC} R_B \quad \text{... (7)}$$

In this equation, μ_{ij} is the friction coefficient between parts i and j.

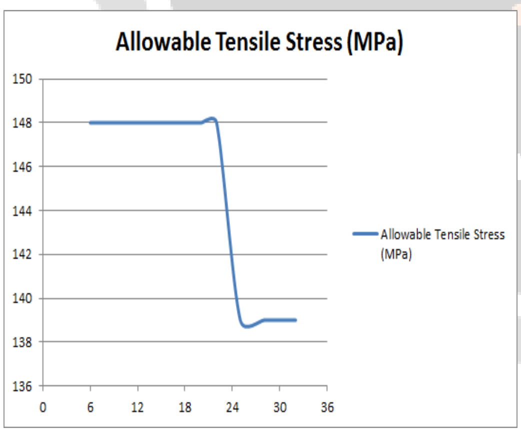
In the friction laws, there are less than or equal signs because movement only occurs once the tangential force reaches µ times the normal force. If the tangential force is lower, no displacement occurs, despite its value. With this value, the Gripping force of the grips on the specimen can be calculated as follows:

$$F_G = F\frac{\cos\alpha - \mu_{BC}\sin\alpha}{\sin\alpha + \mu_{BC}\cos\alpha} + R_A\frac{(1-\mu_{AC}\mu_{BC})\cos\alpha - (\mu_{BC} - \mu_{AC})\sin\alpha}{\sin\alpha + \mu_{BC}\cos\alpha} \quad \text{... (8)}$$

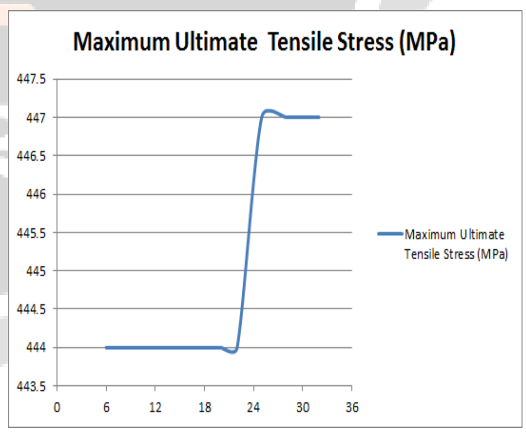
Here by change in the design of gripper gripping force is about 439.19 KN which is higher than previous design of gripper in which there was gripping force was is about 212 KN. So for that purpose it will give advantage to holding rebar.

4. MATHEMATICAL ANALYSIS

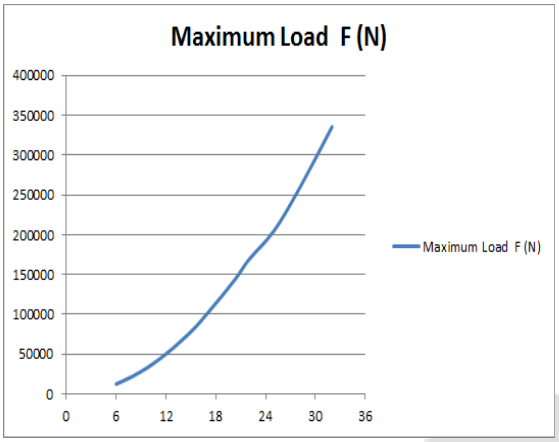
Mathematical analysis of gripper can only possible by considering gripper parameters which affects gripper design .Gripper parameters can be consider as Rebar diameter, Allowable tensile stress ,Maximum ultimate tensile stress ,Maximum load ,Reaction force Gripping force .



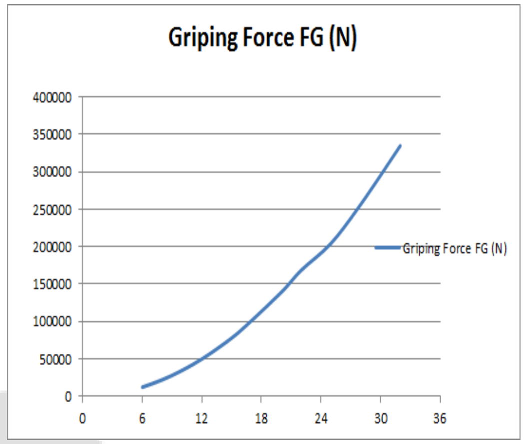
(a) Allowable Tensile Stress



(b) Maximum Tensile Stress



(c) Maximum load



(d) Gripping Force

Figure 8: Mathematical analysis of gripper

5. GRIPPER MODEL

EXISTING DESIGN AND NEW DESIGN OF GRIPPER:

(i) Existing model of Gripper

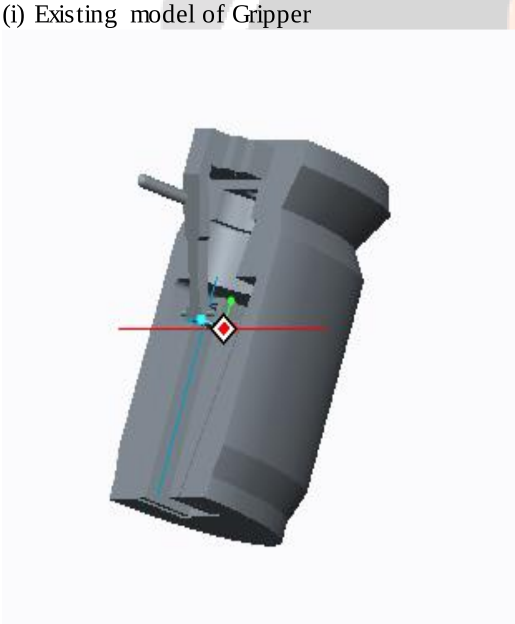


Figure 9: Existing gripper model

(ii) New model of Gripper

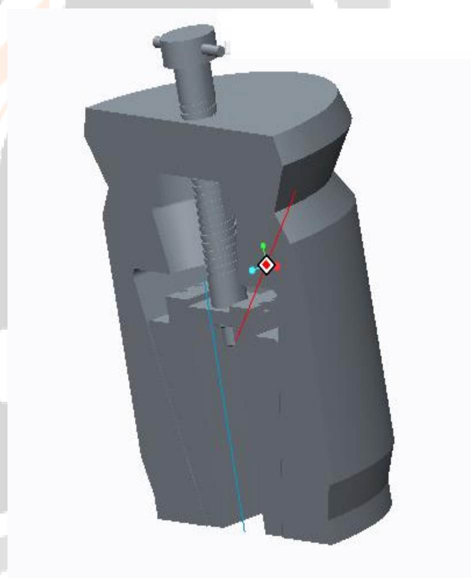


Figure 10: New gripper design model

Static analysis of mechanical wedge inserts:

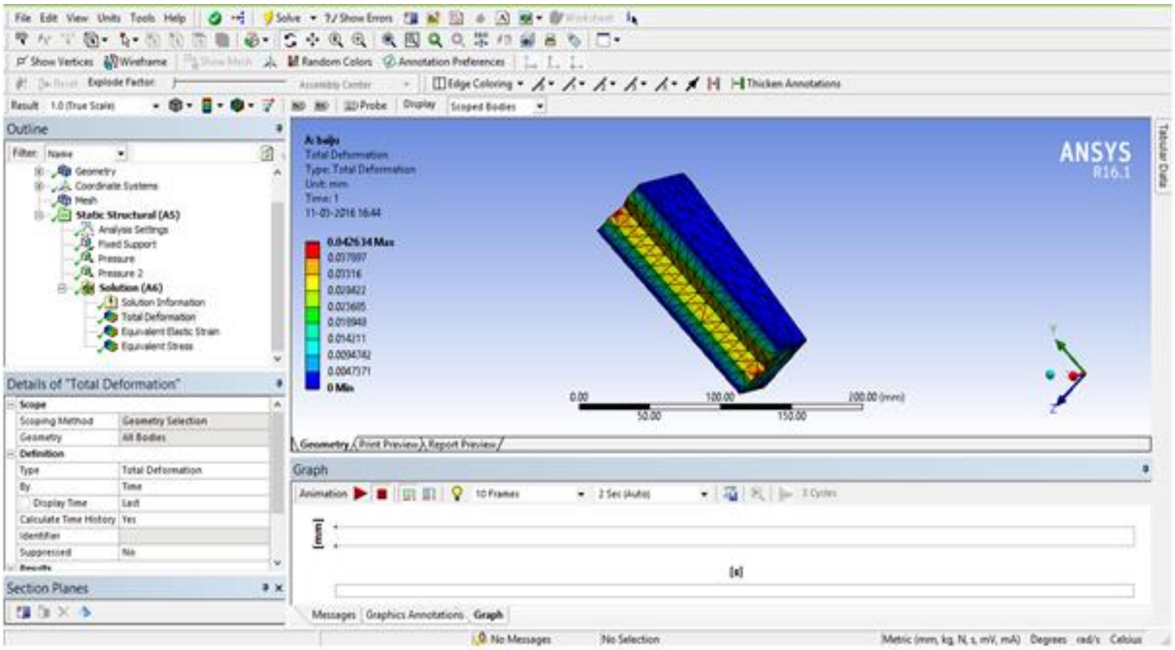


Figure 11: Deformation on mechanical wedge insert

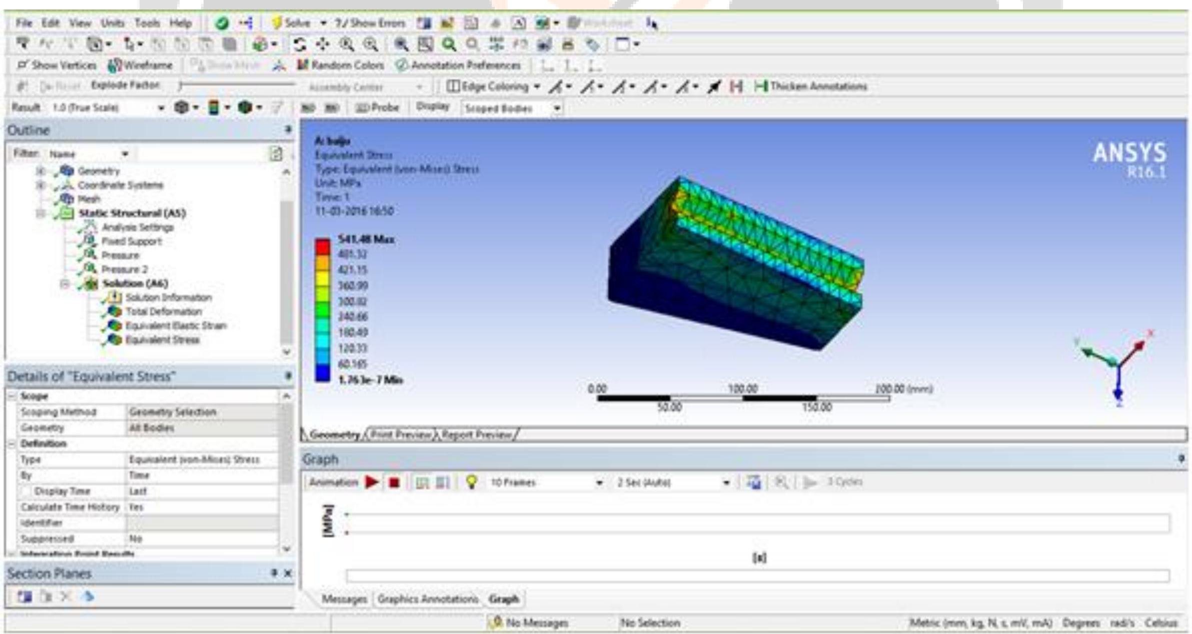


Figure 12: Stress analysis on mechanical wedge insert

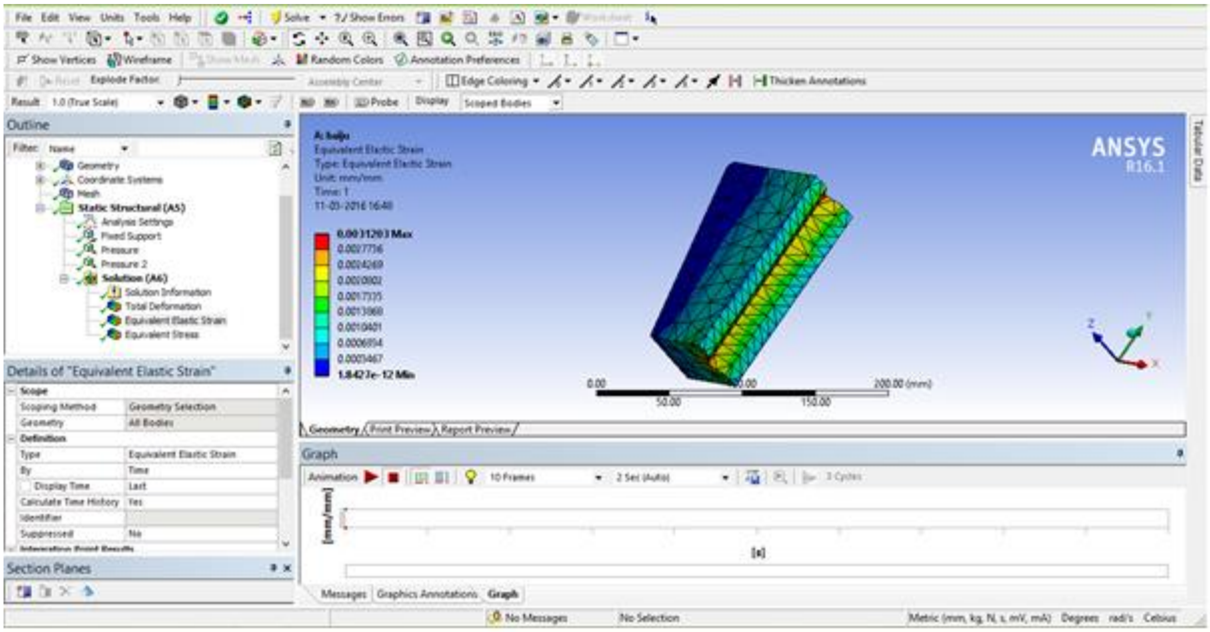


Figure 13: Strain analysis on mechanical wedge insert

CONCLUSIONS:

-UTM has fixtures for holding the test specimen called gripper in which the both ends of the test specimen fitted.

-When there is change in the design of gripper, it is possible to increase the gripping force due to which there is increase in the holding capacity of gripper.

-Gripping force exerted by wedges of the gripper is within permissible limit.

-Designing wedge area required to hold larger diameter Rebars is higher in compare with smaller diameter rebar.

-It can be also consider as with the help of threaded grips, the holding capacity of thread holds about 35% of the total load.

- ANSYS analysis indicates that design parameters for gripper like Deformation, Stress and Strain for newely design gripper are within permissible limits.

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