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Development of a GUI Based Program for Design of various Steel Connections

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Abstract: ***Steel frame buildings consist of a number of different types of structural elements. Every element must be attached properly to its neighbouring part of structure. This will involve use of various types of connections. Connections account for more than half the cost of structural steel work. Connection failure is not a ductile failure and hence it should be avoided before member failure. Large uncertainty is there in the design of connections. Connections are usually the most vulnerable part of the structure, failure of which may lead to the failure of whole structure. Thus, design of connection is an important and integral part of design of the steel structure. This MATLAB GUI program developed will be a very useful and user-friendly tool for the design of connections.***

Keywords: GUI, MATLAB, shear connection, Web Angle, fillet weld, eccentric connection, seat connection

I. INTRODUCTION

Unlike concrete, connections in steel structures need special design. Mainly three major connections are there: - bolted, welded, riveted but rivets are now seldom used. Steel connection calculations are the most complex and time-consuming phases of the steel structural design. This long and complex process requires precision and efficiency and can become a source of errors with unwanted consequences. This MATLAB GUI program can help reducing time in these complex calculations and also human calculation errors. This can increase precision and accuracy in design process. GUI is a very user-friendly tool and it can be easily used by people. In industry it can of great benefit as it will reduce the long-time consuming process. Connections should satisfy the requirements of structural behaviour. They should be strong enough to transmit the design loads and at the same time have the intended degree of flexibility and rigidity.

There are various types of steel connections based on following: -

1) On the basis of connecting medium: -
a) Bolted
b) Welded
c) Riveted
2) According to nature and location of load: -
a) Direct shear connections
b) Pure moment connections
c) Eccentric connections
d) Moment shear connections
3) According to the type of structural elements: -
a) Single plate angle connections
b) Double web angle connections
c) Top and seated angle connections
d) Seated beam connections
4) According to type of members joining:
a) Beam to beam connection
b) Beam to column connection
c) Column base plate connection
d) Column to column connection

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Various types of steel connections are analysed and GUI program is developed for design of connections. Classification of connections is show in the figure below: -

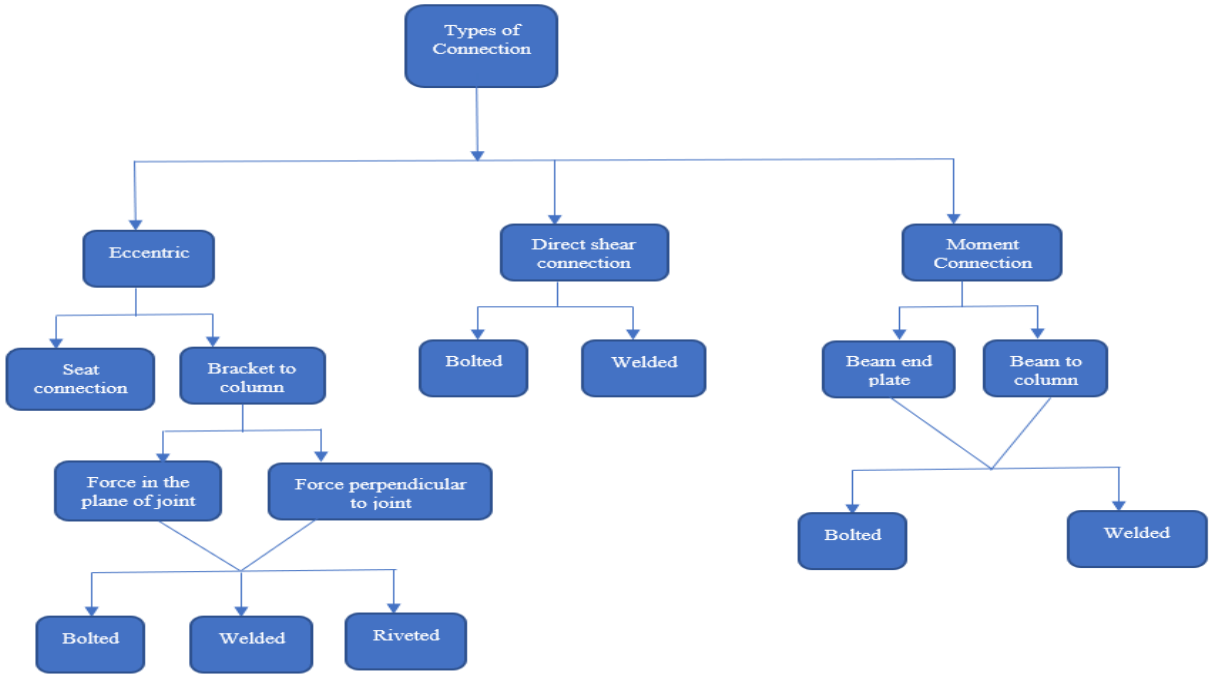

Fig. 1 Division of connections

II. DESIGN METHODOLOGY

1) Eccentric Connections

1) Load lying in the Plane of Joint

a) Riveted Connection

- First number of rivets is found out using the direct axial shear

  No of rivets=1.25*P/R;

  R=rivet value.

  P= shear force

- Then from bending stress the number of rivets is found out

  Number of rivets in a line = $\sqrt{\frac{6M}{mpR}}$

  Where, M=moment

  m= no. of rivets line

  p=pitch

  R=rivet value

  Thus, total rivets=m*n

- Check if force in extreme rivet is under limit of rivet value.

b) Welded Connection

- Force from direct shear and bending is found out in terms of throat thickness of weld
- Resultant force is found out
- Equating the resultant force with limit of weld(108Mpa) throat thickness is found
- Size of weld=t/0.707

2) Load Perpendicular to Joint

a) Welded Connection

- Same process as for load lying in the plane of joint except that for forces are perpendicular to each other.

Force due to bending =M*y/I;

i.e.

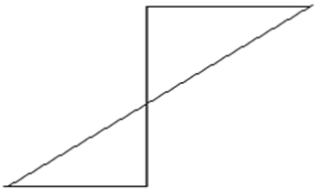

Fig. 2 Stress diagram of weld

Thus, maximum force due to bending develops in the top portion of the joint. The resultant force for that part is found.

F_a (stress due to direct shear) = factor load/area of weld

The resultant of the stresses should be less than the maximum stress limit of weld (108 MPa). Equating the force with this value we can find out the size of weld.

III. DIRECT SHEAR CONNECTIONS

1) Bolted Connection

1) Between Plates:

- First bolt value is found out considering whether bolt is in single shear or double shear
- Then number of bolts is found out by dividing factored load by bolt value
- End distance and pitch is calculated considering the codal provision of IS800:2007

2) Welded Connection:

1) Fillet weld:

- Design strength of fillet weld is calculated on its throat area using the formula

$$P_{dw} = \frac{f_u L_w t_e}{\sqrt{3}\gamma_{mw}}$$

Where, P_{dw} = design strength of weld

L_w =

- End returns of length equal to twice the size of weld are provided at each end of longitudinal fillet weld

2) *Butt Weld:*

- When plates to be joined are in the same plane then butt weld is used as shown below: -

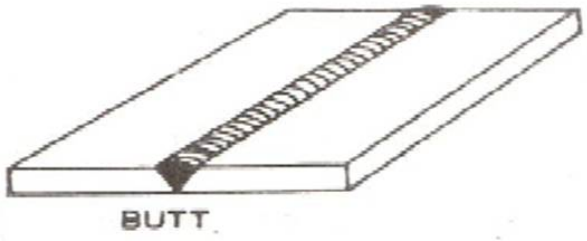

Fig. 3 A typical butt weld

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IV. RESULTS AND DISCUSSION

GUI codes for different types of connection are made and shown below.

A. Types of connections

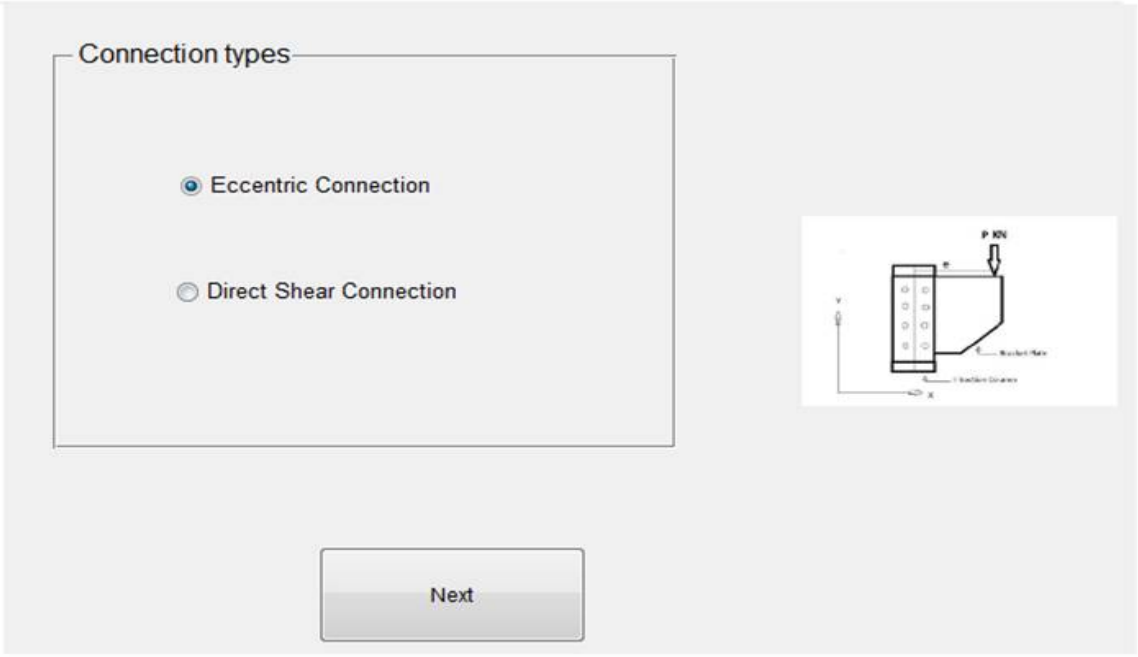

Fig. 4. Types of connections GUI

1) Eccentric Connection

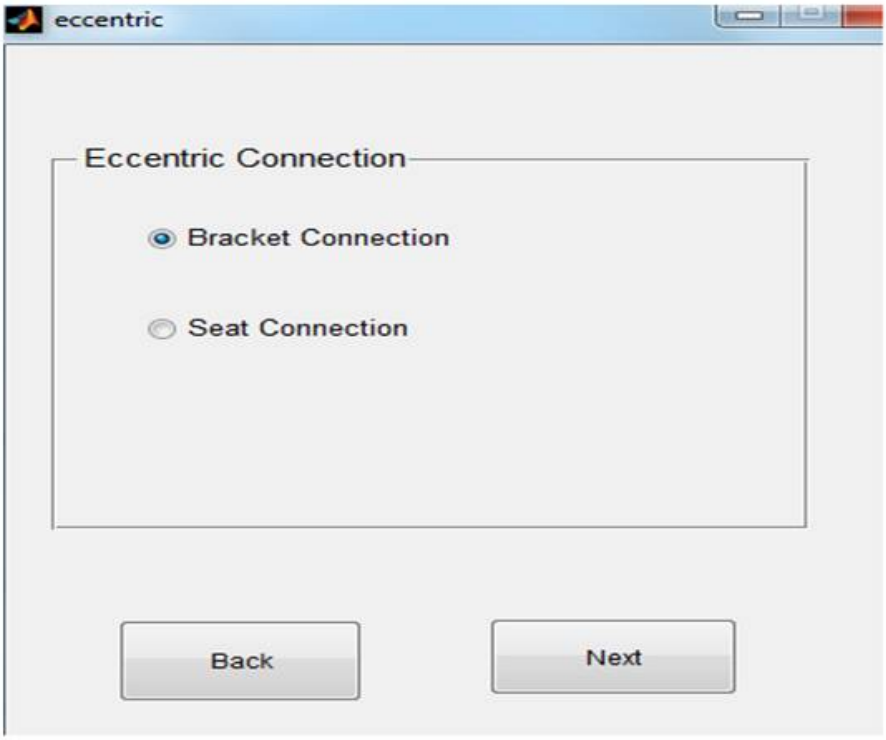

Fig. 5. Eccentric connection types GUI

a) Bracket Connection: Different types of bracket connections design are made in GUI as shown in the figures below: First, we have interface for choosing types of bracket connections.

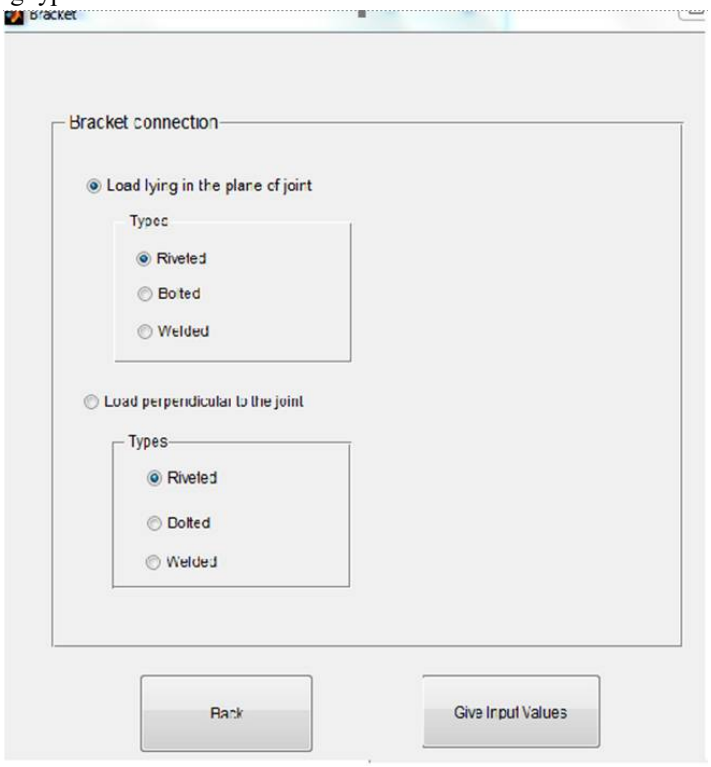

Fig. 6. Types of Bracket connections GUI

We have two cases for bracket connection: - a) load lying in the plane of joint and b) load perpendicular to the joint

b) Load Lying In The Plane Of Joint

- Riveted connection

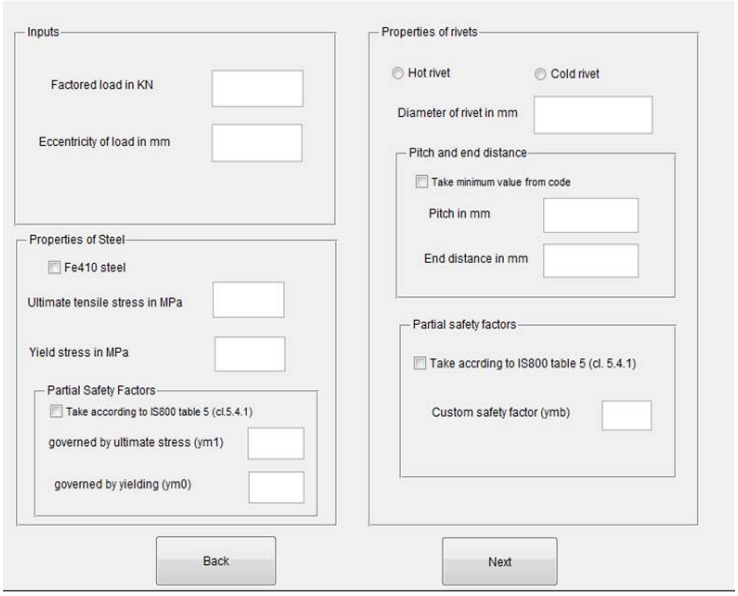

Fig. 7 rivet connections for load in plane of joint GUI

Given the below sample inputs, we can find the number of rivets and check it for extreme force developed in the extreme of rivet.
Sample input: -
Eccentricity = 160mm
Factor load = 225KN
Hot rivets and cold rivet show whether rivets are in pretension or not.
Results: - 2*8 no of rivets. 8 in each line.
And it is safe to carry to above load

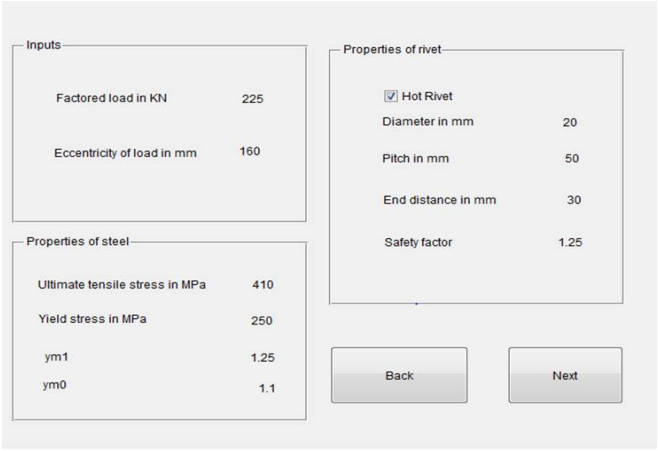

Fig. 8 Value check for above GUI

Fig. 9 Result for the above case

- *Welded connection*

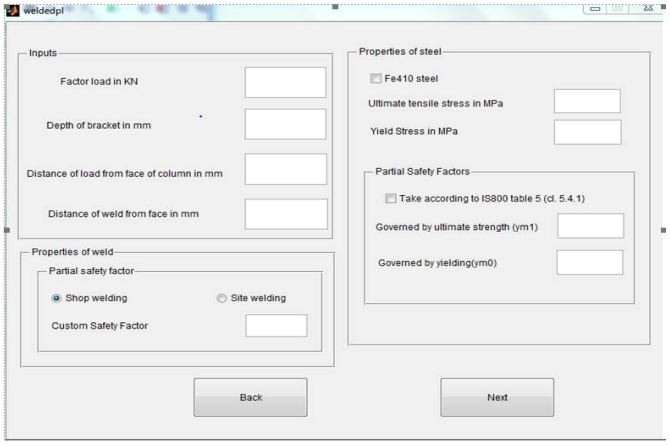

Fig. 10 Welded connections for load in plane of joint GUI

Giving the input value and finding the weld size. First the value is checked and then result is then found out.

Direct shear stress and maximum shear stress due to bending is calculated and resultant stress is calculated and from where thickness of weld is calculated.

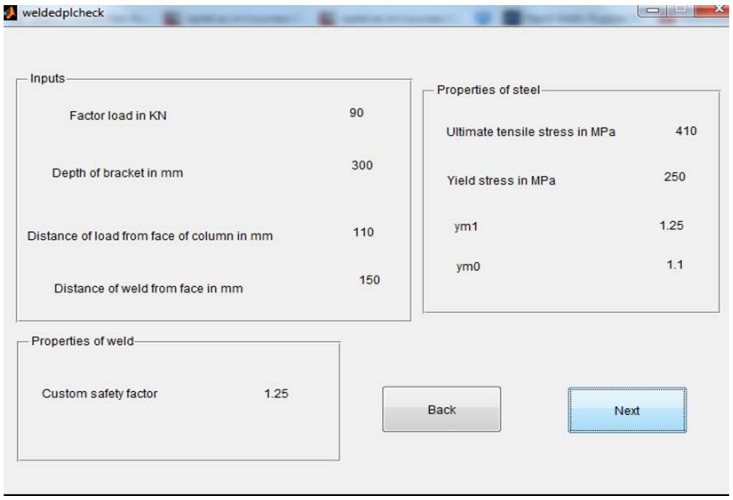

Fig. 11 Values check for above case

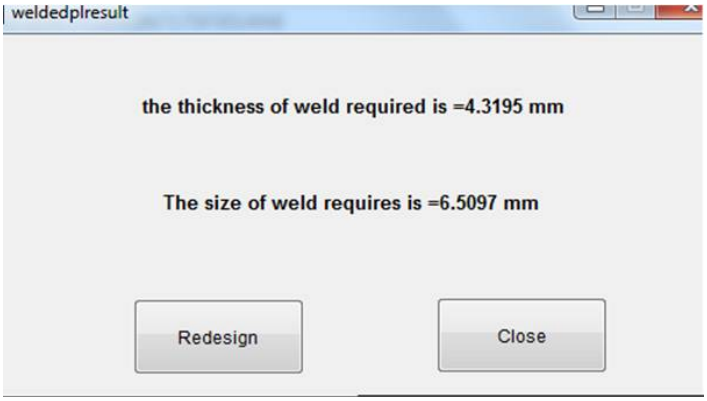

Fig. 12 Result for above case

c) Load Perpendicular To Plane Of Joint

- *Welded Joint*

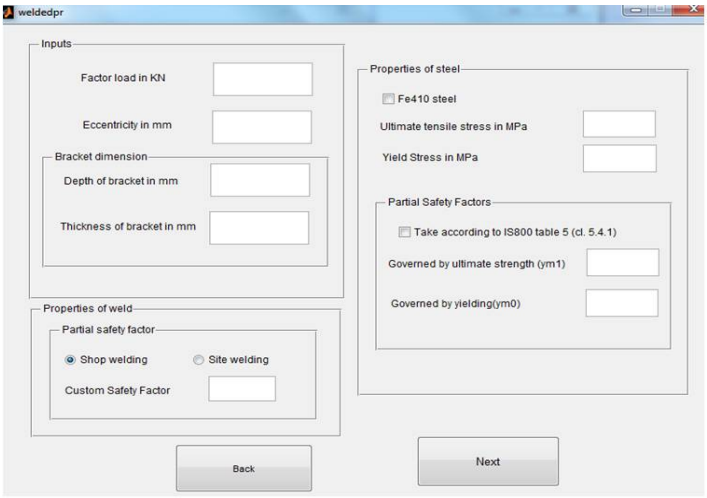

Fig. 13 Weld joint for eccentric load perpendicular to the plane of joint GUI

Check for value for some input case and then get the result

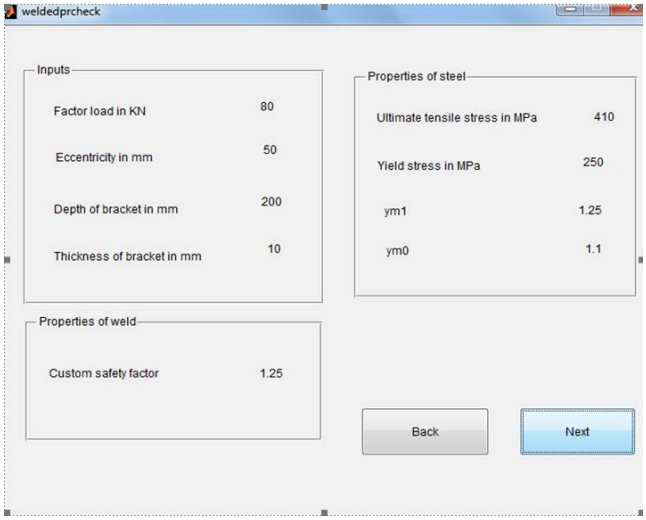

Fig. 14 check for value of above case

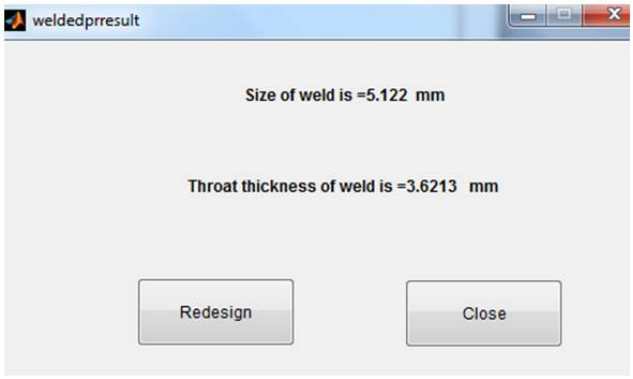

Fig. 15 Result for above case

d) Seat Connection: This is another type of eccentric connection.

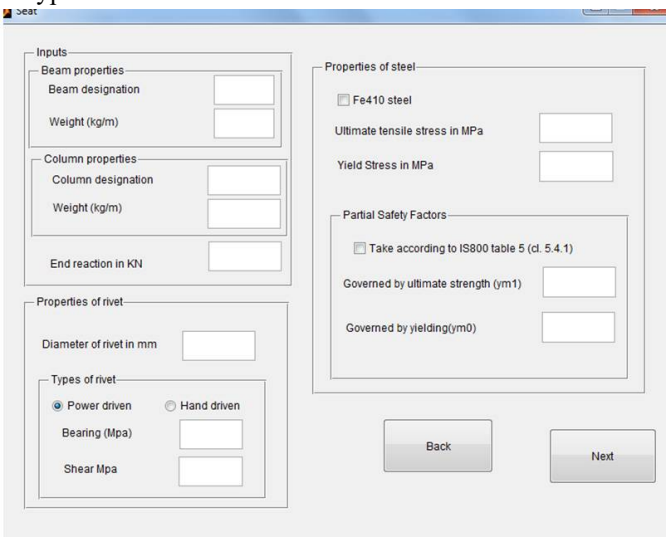

Fig. 16 Seat connection design GUI

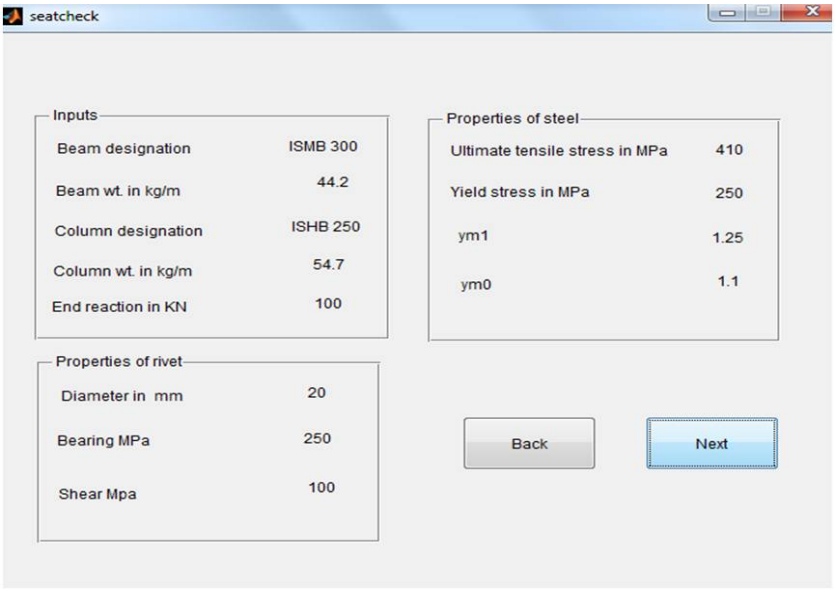

Fig. 17 Value check for above case

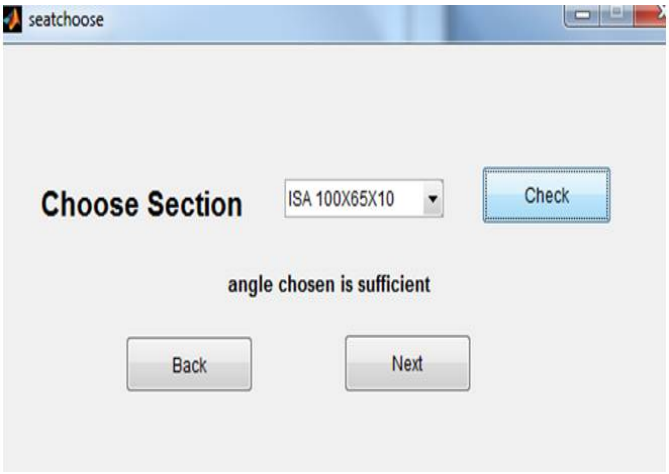

Fig. 18 Angle choice GUI for above case

Fig. 19 Result for above case

2) Direct Shear Connection

a) Bolted Connection: we will consider two cases for this connection one will be between plates and another will be between plate and angle.

- *Between Plates*

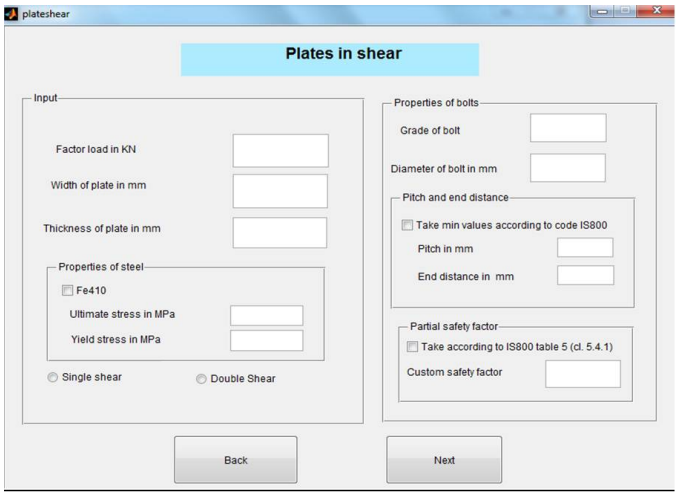

Fig. 20 Shear bolted connection for plates GUI

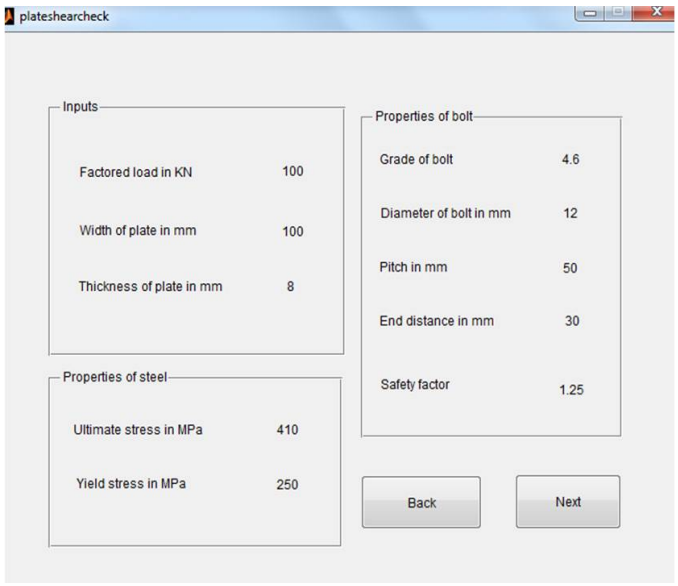

Fig. 21 Value check for above case

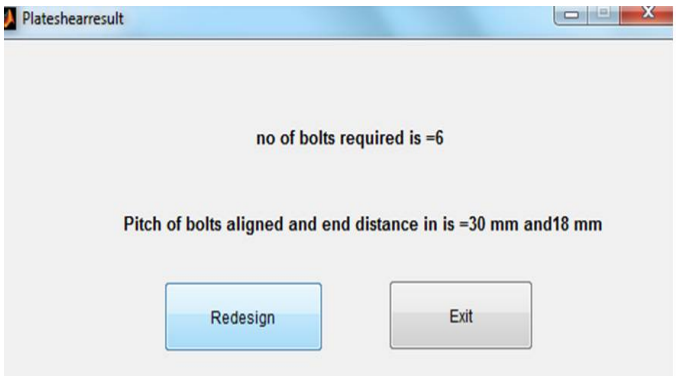

Fig. 22 Result for above case

- *Between Angle and Plates*

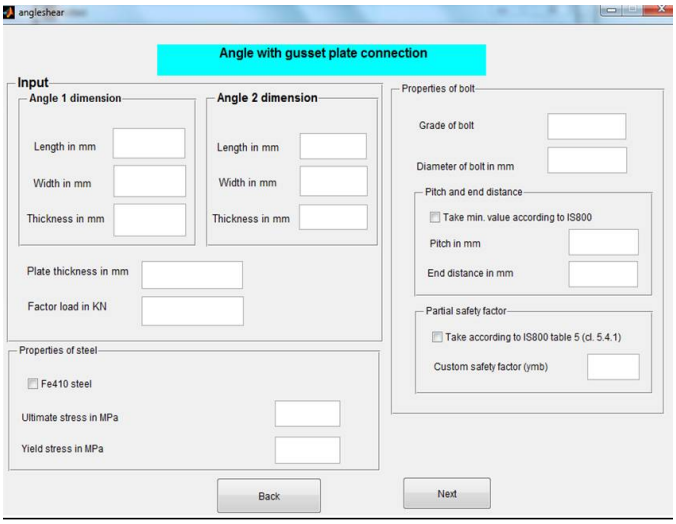

Fig. 23 Result for above case

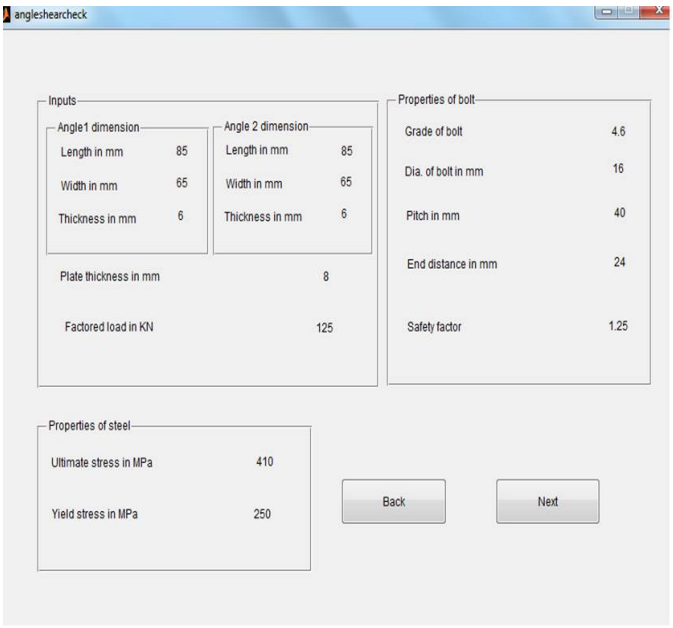

Fig. 24 Shear bolted connection between angle and plate

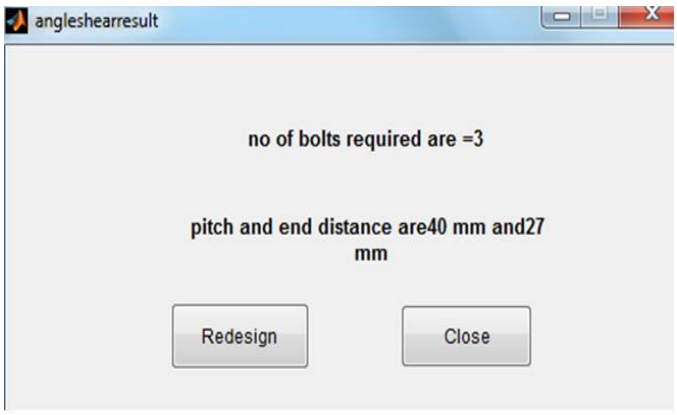

Fig. 25 Result for above case

b) Welded Connection: Two types of welded connection are designed.

- *Fillet weld design:* - fillet weld is used for lap joint and tee joint. A typical fillet weld is shown below:

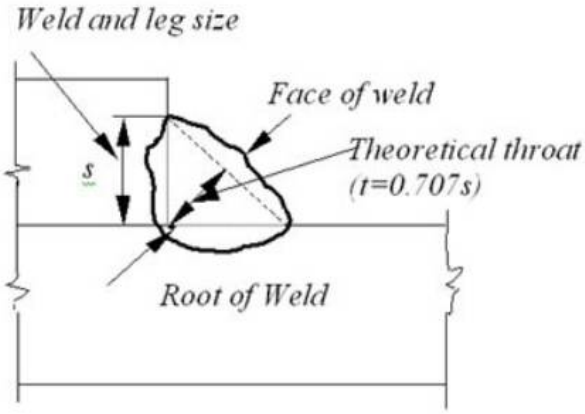

Fig. 26 A typical fillet weld

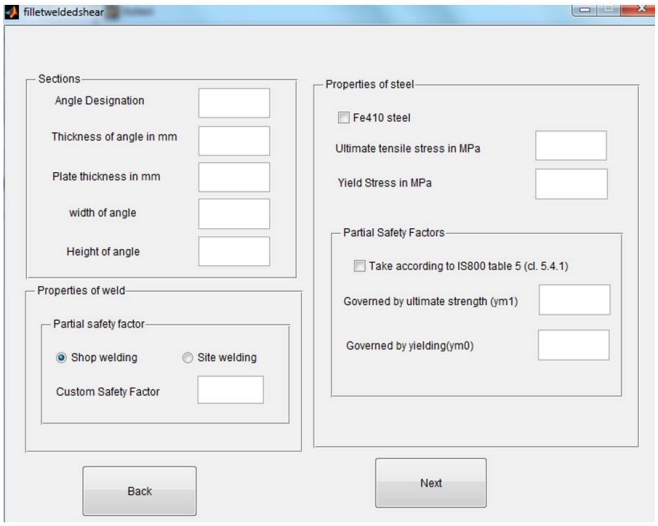

Fig. 27 Fillet weld design for shear connection GUI

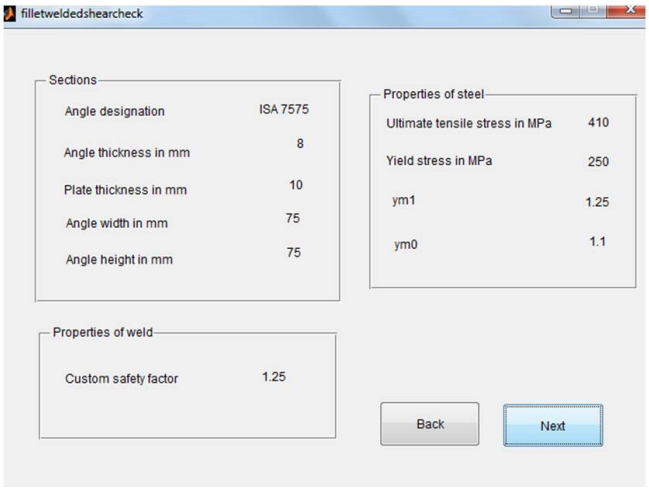

Fig. 28 Value check for above case

Fig. 29 Result for above case

- *Butt weld design:* - Butt weld is mainly used to connect members which are in the same plane. A typical butt weld is shown below:

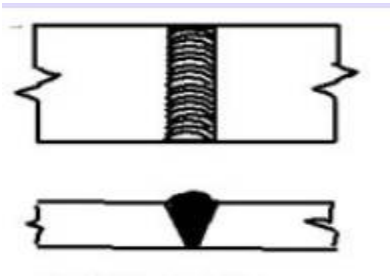

Fig. 30 A typical butt weld

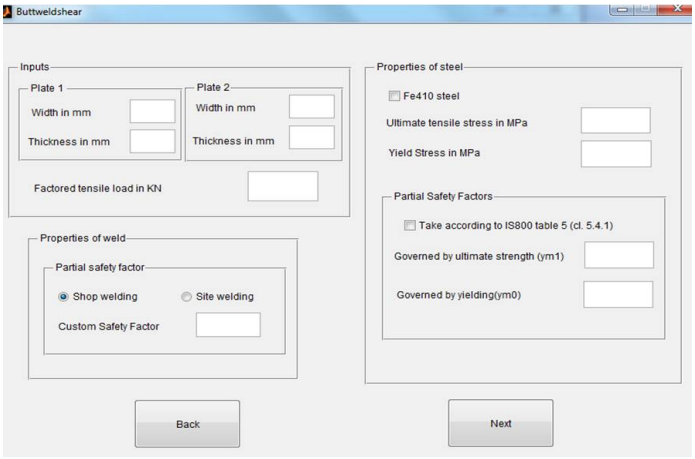

Fig. 31 Butt weld design for shear connections GUI

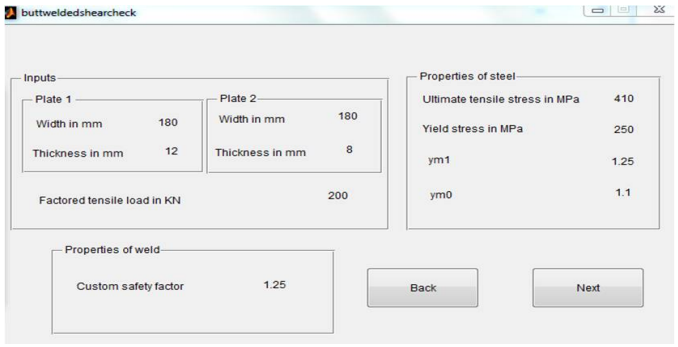

Fig. 32 Value check for above case

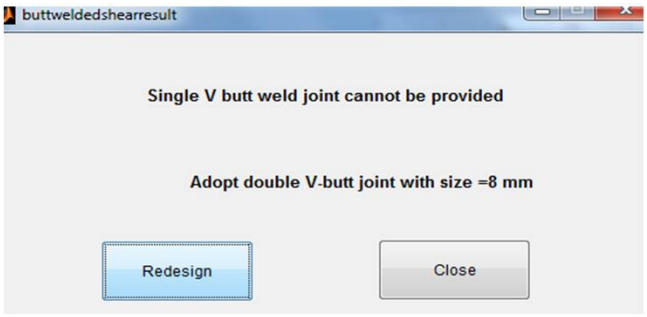

Fig. 33 Result for above case

IV. CONCLUSION

This GUI program made can be very helpful in industrial sector. Connections account for more than half of structural steel work. This program is very user friendly and easy to handle. It finds out the number of bolts and size of welds for various types of connections.

V. ACKNOWLEDGEMENT

I am highly indebted to my Guide Professor Dr. Damodar Maity Sir for his guidance throughout the project. Again, author wishes to thank Math works and MATLAB for providing platform for developing this software.

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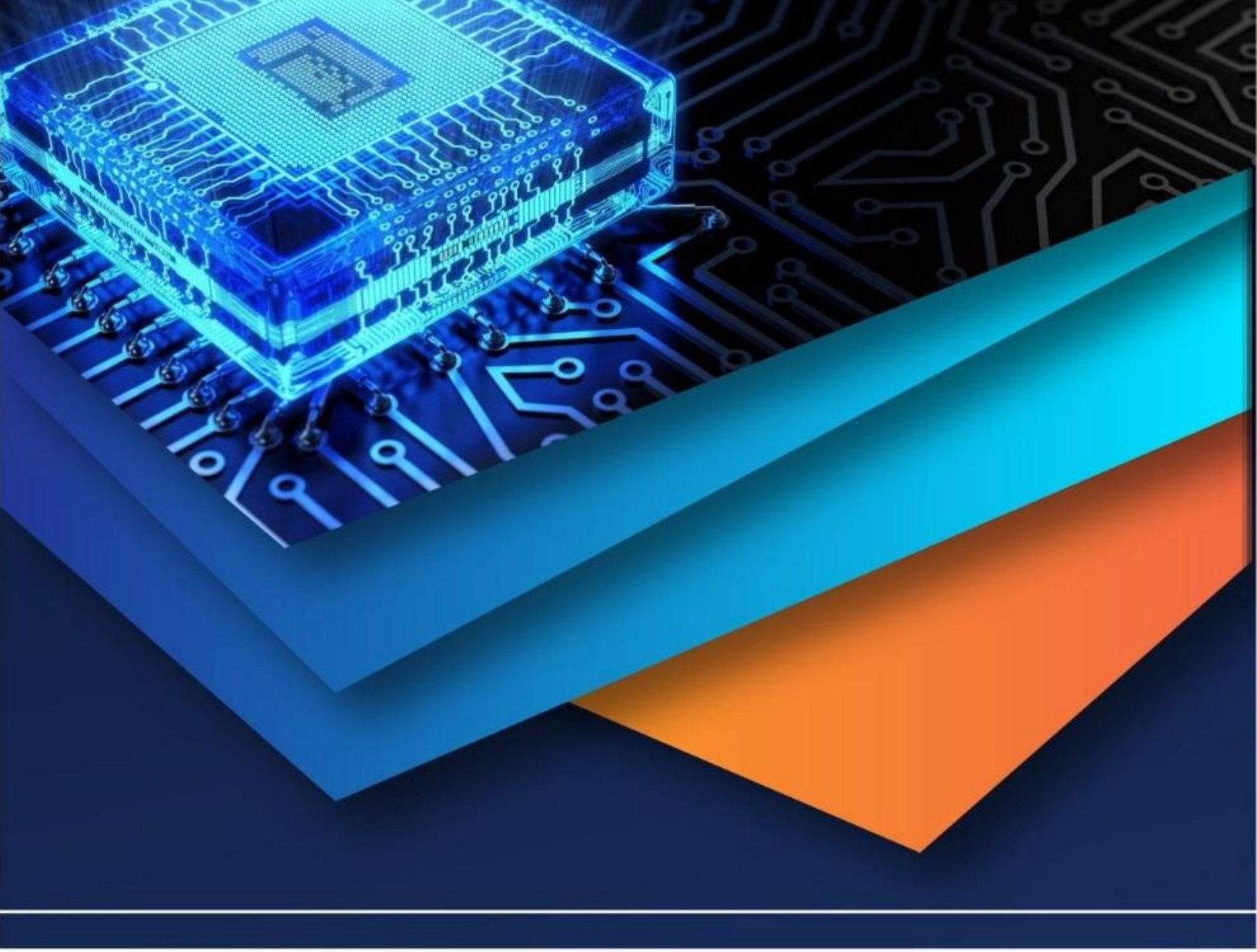

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