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# Effect of Perforation in Channel Section for Resistibility against Shear Buckling

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## ABSTRACT

The steel structure have maximum complexity in designing against load bearing capacity as well as stability to withstand under different types of stresses, thus several types of sections were proposed to enhance stability under variable kind of loads, further channel section and I – sections have maximum capability to resist maximum stress and loads in different conditions. In present investigation analysis is performed on ABAQUS to identify the strength ability during unity load with shear buckling evaluation by performing simulation of shear buckling prediction using ABAQUS/FEM package in channel section with different shape hole in web i.e. circular, elliptical, hexagonal, pentagonal and rhombus, the parameters and results were validated from present previous research work present in literature, these different hole profiles in channel section are investigated for shear stress, deformation, eigen value/shear force, reaction force and shear buckling coefficient. Thus, minimum shear stress is found in hexagonal hole profiled channel section with respect to different hole diameter, IS 808 – 1989 was considered for design of channel section.

***KEYWORDS**: Shear buckling coefficient (Kv), Eigen value/Shear force, Shear Stress, Vonmises Stress, Reaction force, Displacement, Channel Section*

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## 1. INTRODUCTION

In structural engineering, buckling is the sudden trade between structure (deformation) of a structural component under load, such as like the bowing on a column beneath compression then the wrinkling of a pebble underneath shear. If a shape is subjected in imitation of a regularly growing load, then the lay reaches a vital level, a feature might also change structure then the shape and factor is pronounced in conformity with have buckled.[2] Euler's essential burden then Johnson's parabolic components are aged in imitation of decide the buckling accent of slender columns.

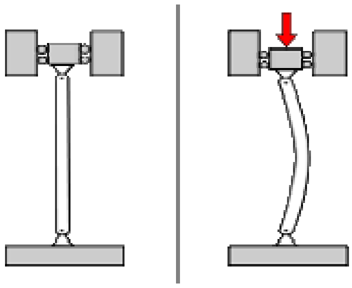


Figure 1.1 – Schematic of Buckling

### 1.1. Shear Buckling

Thin steel plates are commonly used as structural elements in buildings, bridges, towers, aircrafts, etc. Due to their slenderness, these plates are susceptible to buckling under shear loading, thus limiting their capacity. The recent research shows that many existing models do not represent the true mechanics of ultimate shear buckling. This project will investigate and advance the knowledge of shear buckling response, thus leading to improved economy, durability, and safety of structures that use thin plates.

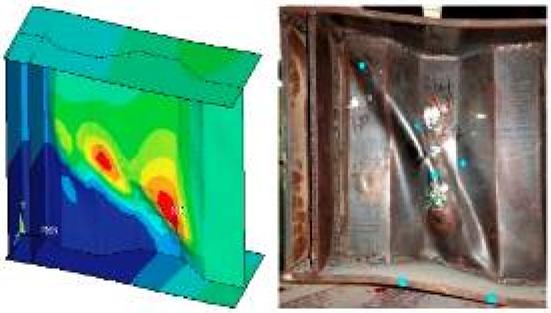


Figure 1.2 – Schematic of Shear Buckling

The overall goal regarding this undertaking is in conformity with comprehensively investigate the mechanics over shear buckling conduct into metal plates, consequently lead to (a) new predictive models to that amount seize the authentic mechanics, and (b) plan adjustments up to expectation expand economy, robustness, or life-cycle performance. The lookup diagram entails both nonlinear finite element studies then pilot tests. A detailed exam on the accent patterns or lay redistribution beside the sprightly buckling stage after the remaining post buckling capacity wish stay the primary focus. Physical checks pleasure discover new panel configurations, or brawny cloth optimizations choice be identified primarily based of perfect issue mechanics studies. Experiments have been conducted using services at Lehigh University in accordance with look at the obtruncate buckling performance concerning steel plate girder specimens, both with or without bending moment. The data out of it tests have been back after directly validate the computational modeling approaches.

## Methodology

### 1.2. Steps to be followed

To achieve the objective of proposed dissertation work following steps is going to be followed:

- Literature survey and problem identification.
- Study of section of steel (Channel section).
- Selection of working material and section.
- Study of shear buckling coefficient of channel section with different hole profiles.
- Validation of FEM model through numerically measured output parameters at unit load in channel section.
- To simulate shear buckling modes in channel section to predict shear stresses and deformation.
- Finding the effective optimized design in channel section.
- Comparison of results and conclusion.
- Report preparation.

### 1.3. Finite Element Analysis (FEA)

FEA stands for Finite Element Analysis and as the name suggest the methodology involves the analysis of finite elements. The whole model is divided into number of finite elements and then all the forces and boundary conditions are applied on these finite elements, and then the results of all these finite elements are combined together to give the output of whole model. For example if a line is representing a beam and we have to analyze that beam as a cantilever then FEA will divide this line representing a beam into number of small segments known as element. Then the effect of boundary condition and forces is studied on each segment and the resultant output is the summation of each segment. FEA analysis can help engineers to analyze complicated models. With the development of computer systems FEA has increased to gain importance, since it saves time and money both.

### 1.4. Steps for the shear buckling analysis

Shear buckling analysis have been carried out by using ABAQUS/FEM.

1. First of all the model i.e the channel section structure are modelled using ABAQUS modeling domain.
2. This model is then proceeded for analysis to the ABAQUS.
3. Meshing (discreatization) of the solid model (channel section) is generated by using the meshing function of the ABAQUS finite element solver package.
4. Then boundary conditions are applied to the model and solved for shear buckling modes, shear stresses and deformation.
5. Shear buckling stress is analyzed in channel section and plate (Validation model).

### 1.5. Boundary Condition

- **Load**

1. Load unity is defined.
2. Simply supported effect is imposed at both the ends of channel section.

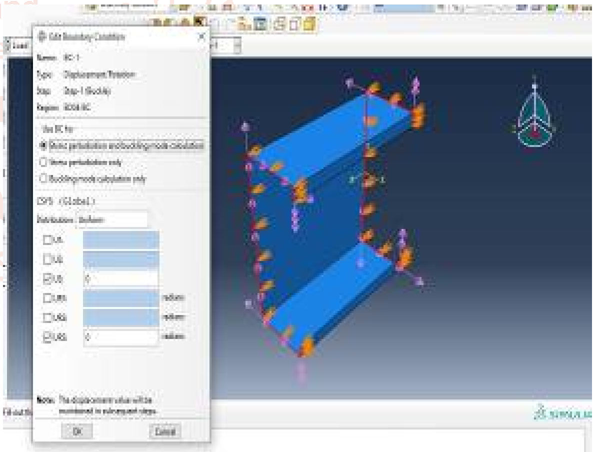


**Figure 1 – Boundary condition (unity load definition)**

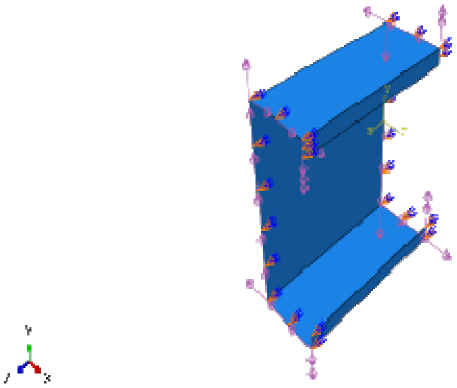
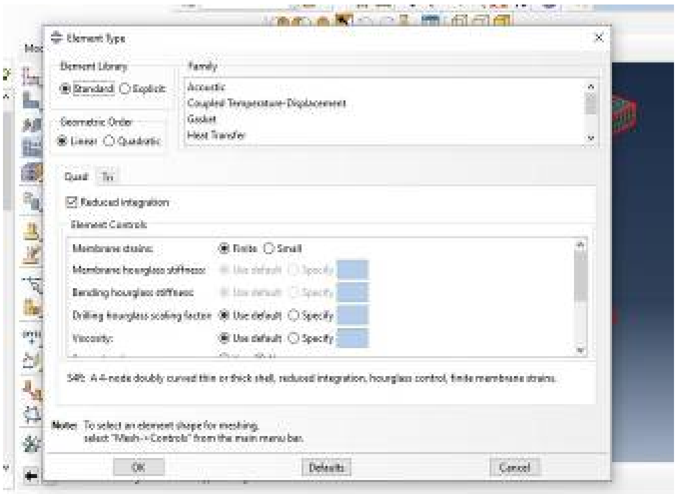


**Figure 2 - Boundary condition (simply support definition)**

### ➢ Meshing details

1. Element type -3D solid element
2. Type of mesh - (Quadrahedral mesh)
3. Number of element- 2497
4. Number of nodes- 5057



S4R: A 4-node doubly curved thin or thick shell, reduced integration, hourglass control, finite membrane strains.

Note: To select an element shape for meshing, select "Mesh->Controls" from the main menu bar.

**Figure 3 – Element type definition in channel section**

## 1.6. Results

### Governing parameters and their effect

From the literature review it is observed that, shear buckling coefficient of channel sectionis based on following input and output parameters:

**Table1: Related input and output parameters**

| **Input Parameters** |
|---|
| Unit load |
| Simply support |
| Buckling prediction |
| **Output Parameters** |
| Critical buckling coefficient (Kv) |
| Shear stress (Mpa) |
| Deformation (mm) |
| Vonmises stress (Mpa) |
| Eigen value/Shear force |
| Reaction force |

**Validation of present existing experimental model:** In order to validate the existing numerical model of the channel section this is used in order to analyze the shear buckling coefficient for the structure modeled in ABAQUS. The shear stress, reaction force, eigen value/shear force and deformation of the channel section without hole (validation model) of the validation results is represents below.

**Table 2: Validation results for channel section**

| (Validation) | | | | | | |
|---|---|---|---|---|---|---|
| Thickness (mm) | Eigen Value/ Shear Force (Validation) | Shear Stress (Mpa) (Validation) | Shear Buckling Coefficient (Kv) (Validation) | Vonmises stress (Mpa) (Validation) | Reaction Force (Validation) | Displacement (mm) (Validation) |
| 1.5 | 187.18 | 20.19 | 9.8 | 102.1 | 595.3 | 1.22 |
| 1.4 | 225.11 | 19.66 | 9.3 | 98.58 | 583.7 | 1.19 |
| 1.3 | 397.94 | 18.61 | 8.6 | 97.33 | 578.2 | 1.12 |
| 1.2 | 457.35 | 16.56 | 7.9 | 93.63 | 573.4 | 9.8 |

**Simulation results obtained for channel section in ABAQUS/FEM for different modes of shear buckling withvonmises stress, reaction force, shear stress, eigen value/shear force and deformation are represented below:**

**Modes of buckling for channel section:**

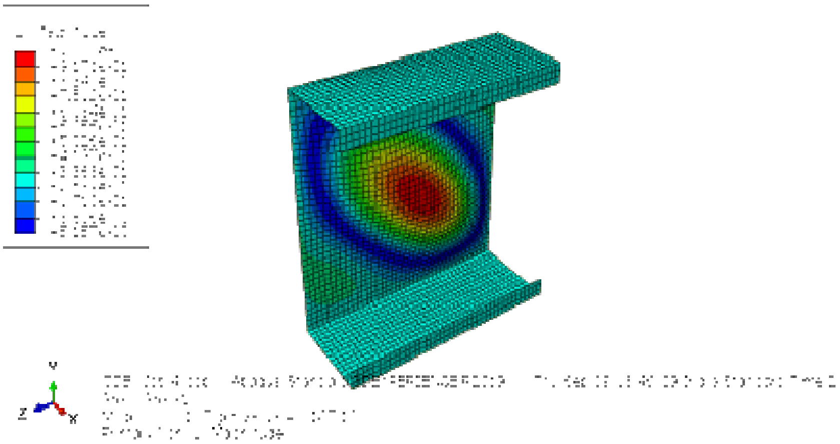


**Figure 4 – Mode shape of shear buckling for channel section (Validation)**

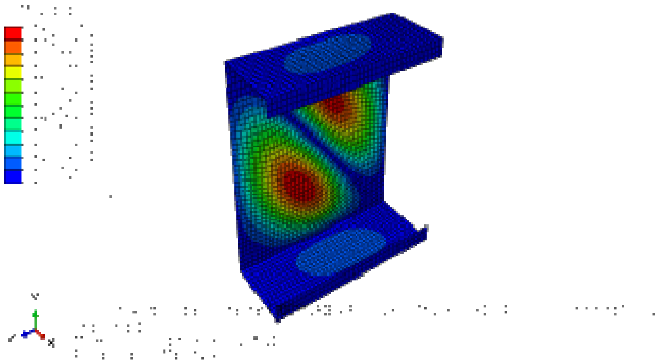


**Figure 5 – Mode shape of shear buckling for channel section (Validation)**

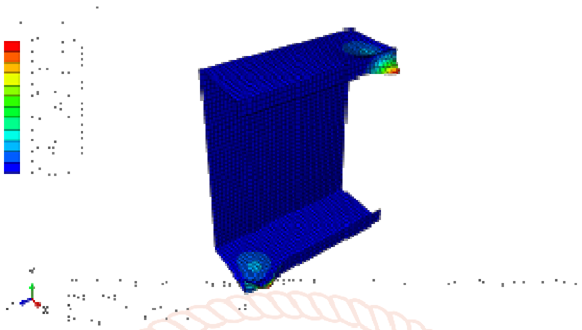


**Figure 6 – Mode shape of shear buckling for channel section (Validation)**

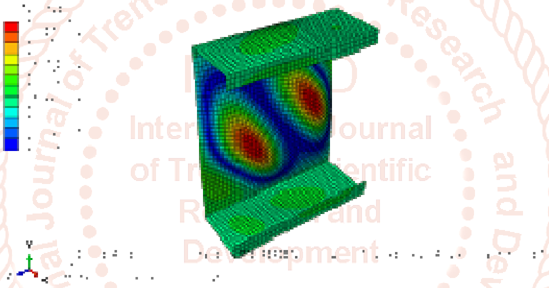


**Figure 7 – Mode shape of shear buckling for channel section (Validation)**

**Simulation results obtained for channel section in ABAQUS/FEM for different output parameters are represented below:**

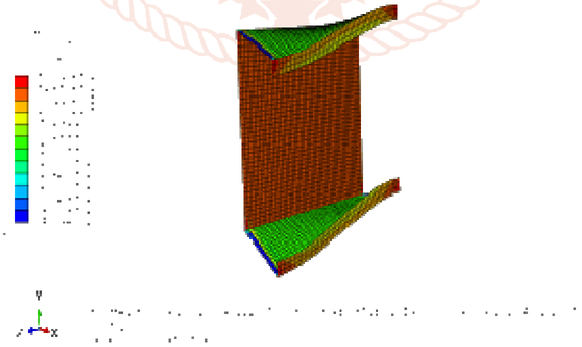


**Figure 8 – Shear stress for channel section (Validation)**

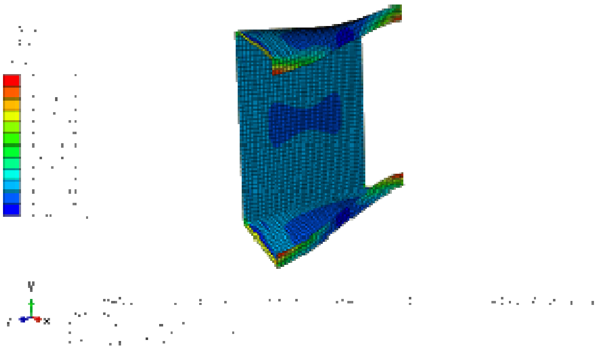


**Figure 9 – Vonmises stress for channel section (Validation)**

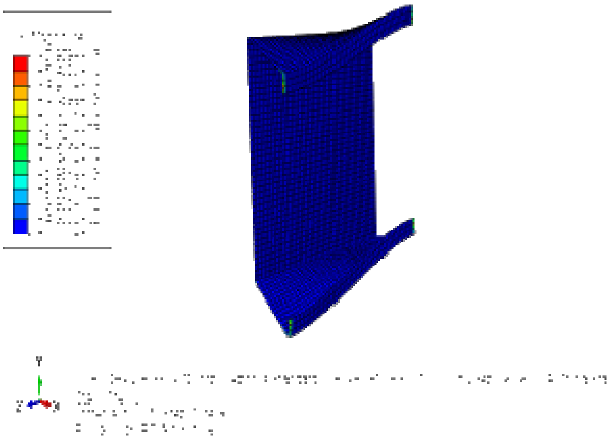


Figure 9 – Reaction force for channel section (Validation)

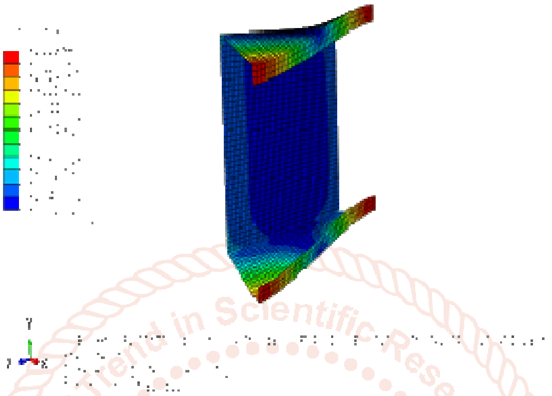


Figure 10 – Deformation for channel section (Validation)

**Overall comparison of output parameters for channel section with circular, elliptical, hexagonal, pentagonal, rhombus shaped hole in web are shown below:**

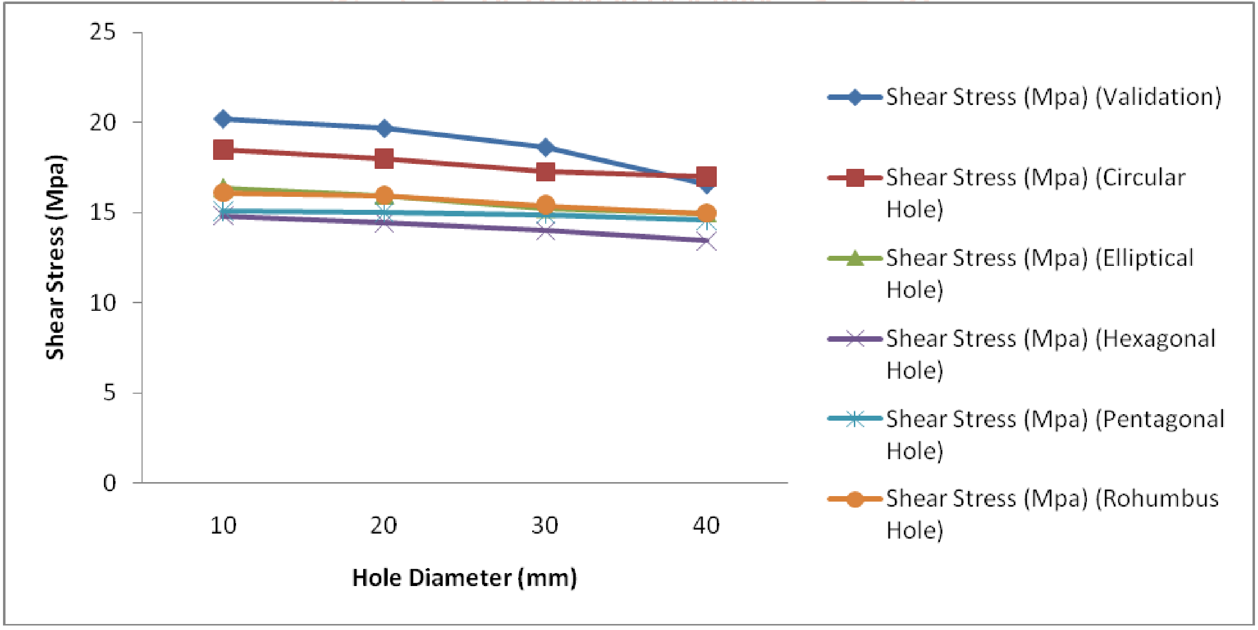


Figure 11 – Overall comparison of shear stress (MPa) with respect to hole diameter

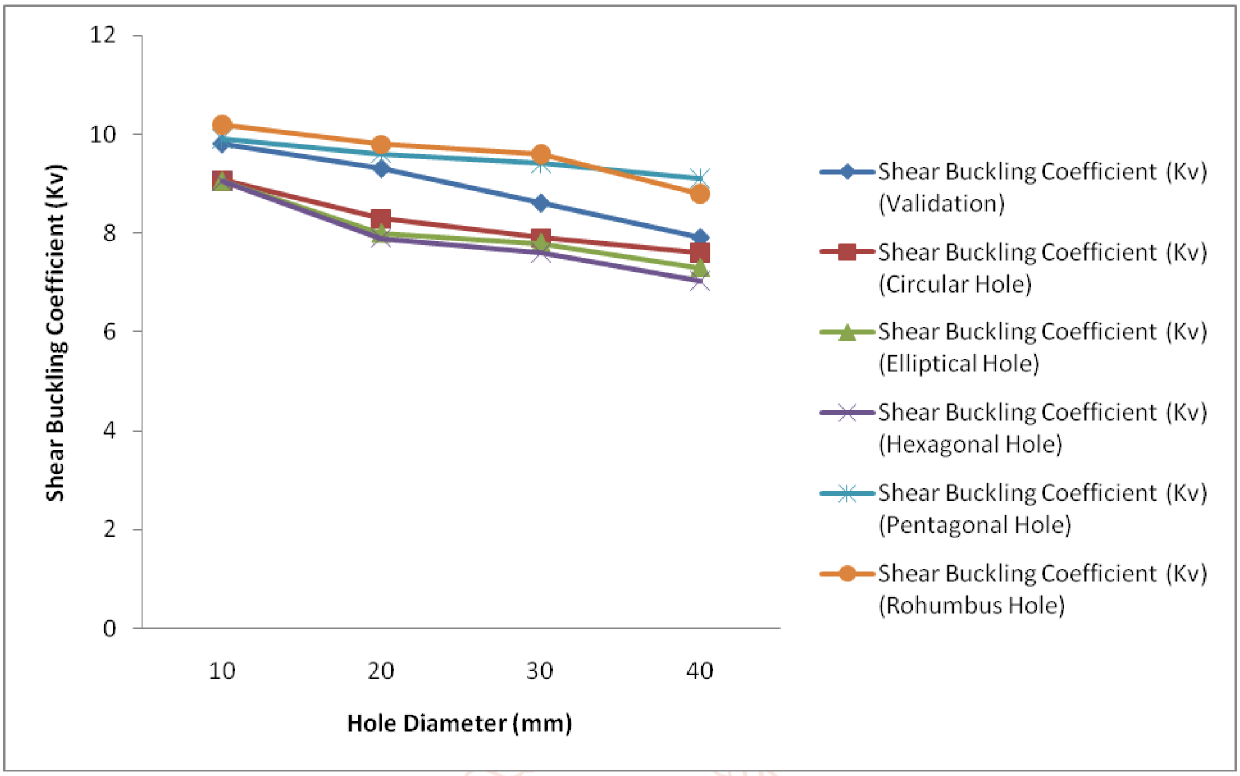


**Figure 12 – Overall comparison of shear buckling coefficient (Kv) with respect to hole diameter**

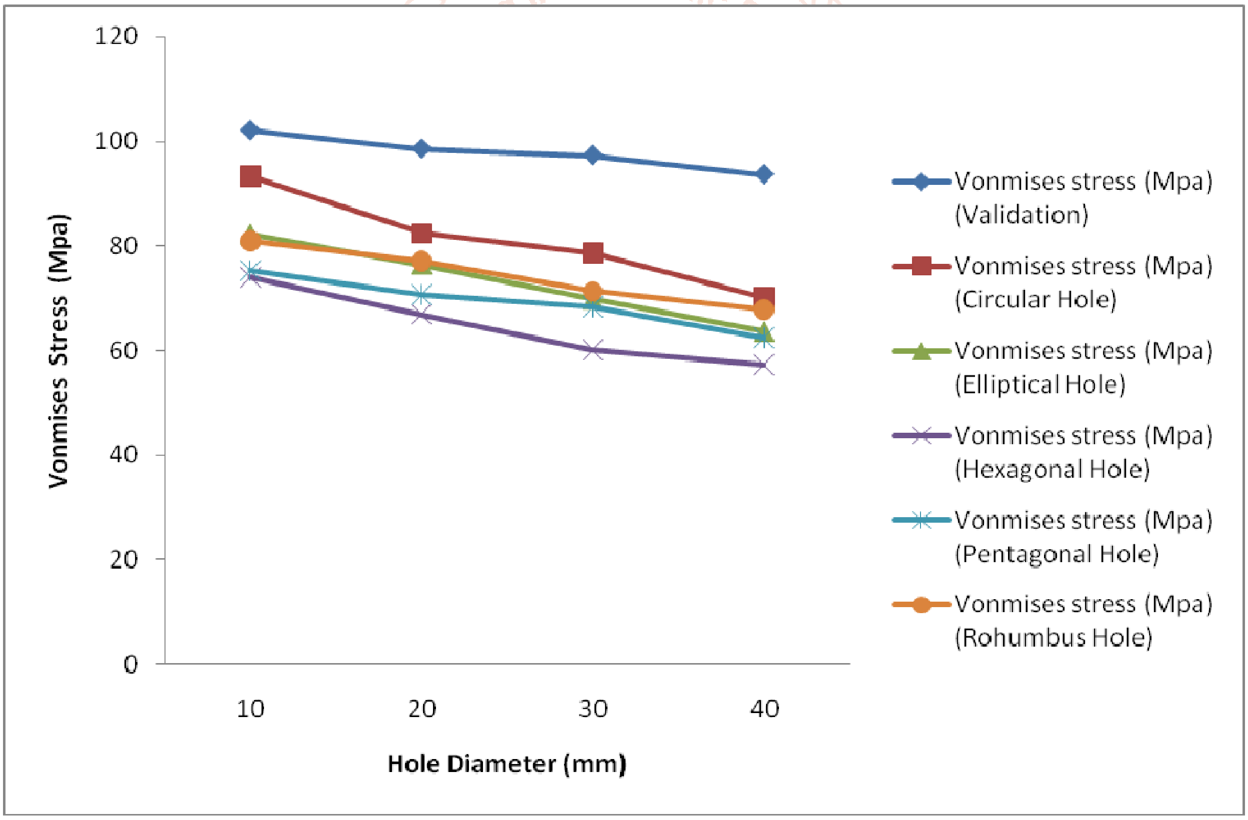


**Figure 13 – Overall comparison of vonmises stress (MPa) with respect to hole diameter**

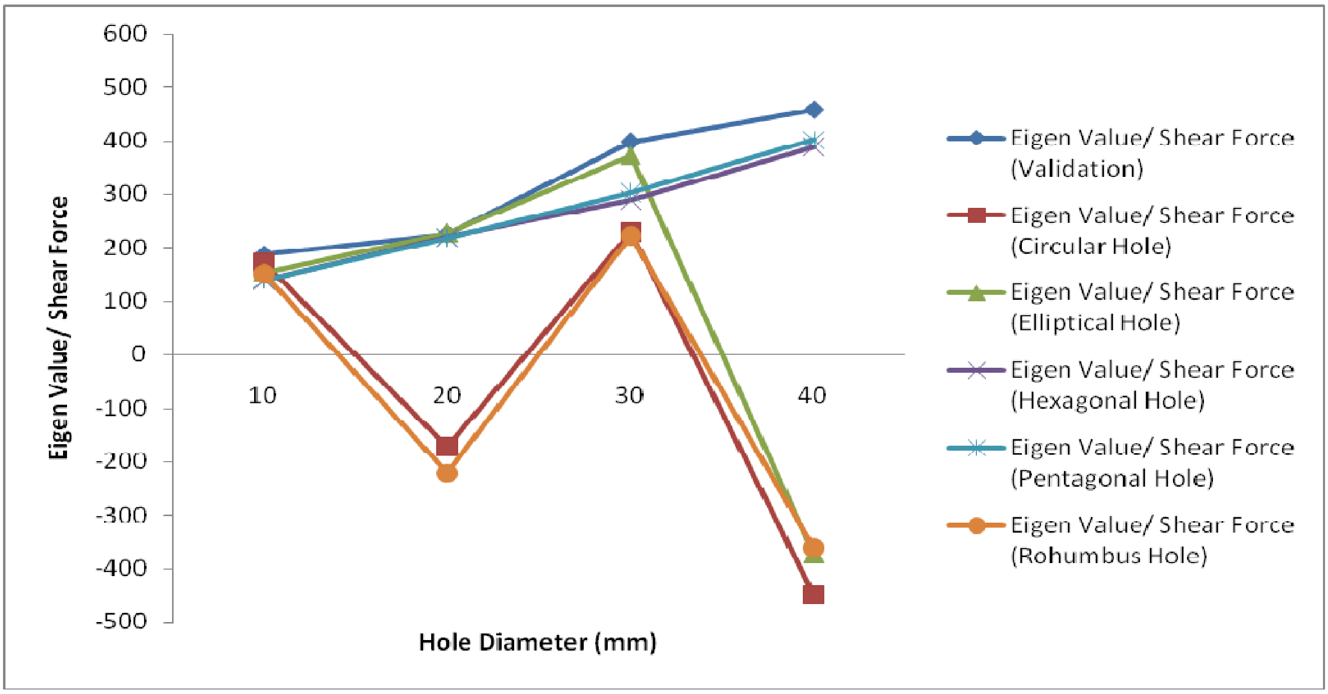


**Figure 14 – Overall comparison of eigen value/shear force with respect to hole diameter**

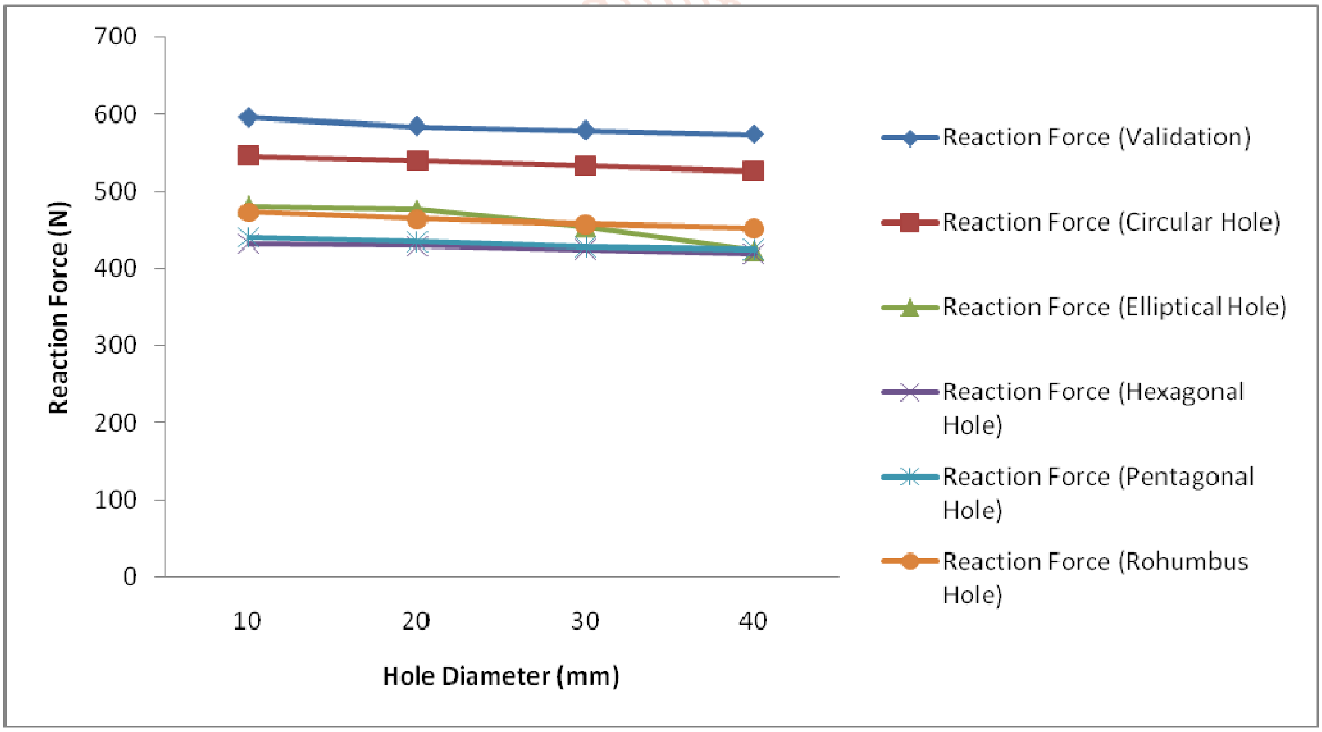


**Figure 15 – Overall comparison of reaction force (N) with respect to hole diameter**

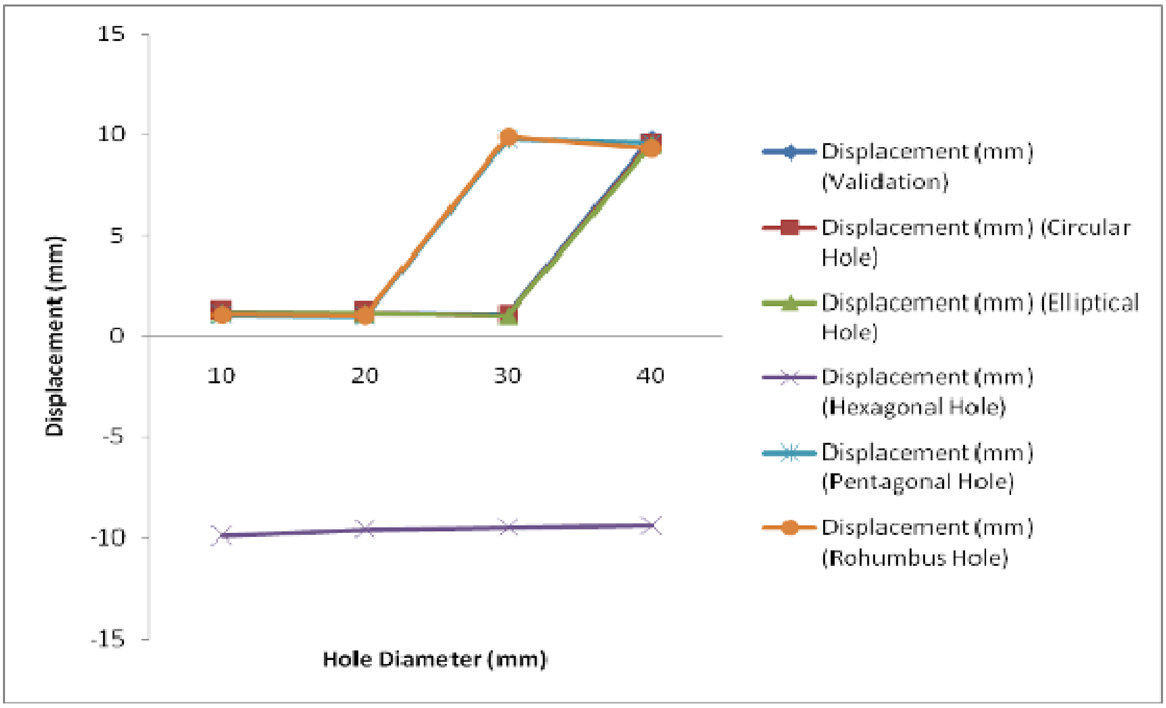


**Figure 16 – Overall comparison of displacement (mm) with respect to hole diameter**

## Conclusion

1. The FEM model was developed on ABAQUS (CAD model domain) and analysis was done by ABAQUS (structural domain).
2. The prediction of FEM model shows good relation with previous research work present in literature.
3. The internal consistency of the results confirms the validity of the FEM model.
4. The shear forces are found to be minimum as increase in hole diameter in channel section profile at certain limit.
5. The eigen value/shear force is found to be increased after 20 mm of hole diameter, thus hole diameter should persist between 20 to 30mm diameter for optimum resistance against shear stress.
6. Minimum shear stress is found in channel section with hexagonal hole profile in web with different hole diameters.
7. The deformation is predicted less in hexagonal hole profile as compared to other configurations.
8. Shear buckling coefficient is minimum for hexagonal hole profile channel section as compared to other shape hole profiles.
9. Channel section with elliptical and pentagonal hole profiles also represents good agreement in shear stress and critical buckling coefficient.

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