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Behaviour of Cold-Formed Z Purlin with and without Edge Stiffener (Lip) in Pre-Engineered Building

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Abstract: Cold-formed steel (CFS) sections are widely used in industrial and non-industrial construction due to its light weight, corrosion resistance, high strength to weigh ratio and economy. Zed and Channel section purlins are commonly used in PEB's. Cold-formed sections are more liable to buckling and flexure because of its minimum slenderness ratio. This paper introduces the buckling behaviour of cold-formed steel Zed purlins with edge stiffeners (lip) when subjected to wind load. Non-linear finite element method (ANSYS R15.0) is used to investigate the behaviour of Zed purlin with and without edge stiffener. Therefore result concluded that 30^0 inclination of edge stiffener (lips) is more desirable than other. But in actual practice edge stiffener of 45^0 inclinations is adopted.
Keywords: Cold-Formed Sections, Non-linear, Edge stiffener, ANSYS.

I. INTRODUCTION

There are two main types of structural members in steel Construction one is hot-rolled and other is cold formed. The cold-formed section is made from steel sheet, strip, plate or flat bar in roll forming machines or by bending brake or by press brake operation. Cold formed steel is adopted over other material like timber and concrete because of:

1) High strength and stiffness
2) Erection and installation is fast and easy.
3) Lightness
4) Non-shrinking and Non-creeping in ambient temperature.
5) Low maintenance.
6) Economy in transportation and handling.

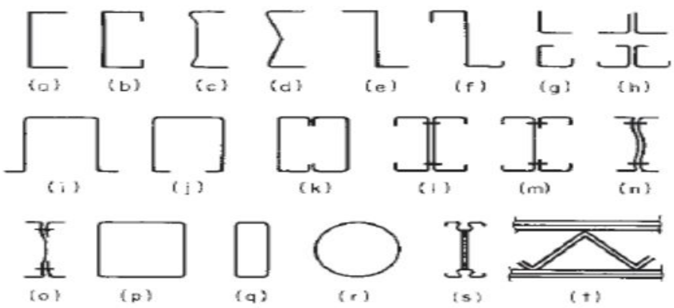

Fig.1 Various Cold-formed Section

The cold-formed steel design is time consuming as the cold-formed materials are susceptible to Local deformation under loads as the materials used are quite thin.Where as in hot-rolled members there is not much to worry about this failure as the materials are thicker than cold-formed.this local deformation comprises of two forms : local buckling and distortional buckling.when the stress reach the certain limit some part of the compression flange and the web buckles which is termed as local buckling.Although in distortional buckling the compression flange and the adjacent lip moves away from their original position resulting in weaking the section.

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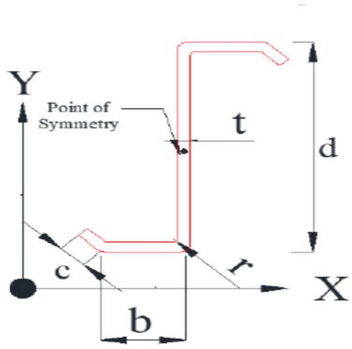
A. Purlins

Purlins are the secondary framing of Pre-engineered building where it transfer load to the primary frame. Purlins are the beams provided to support the roof between the adjacent trusses. Angle sections, channel sections, Z sections are commonly used purlins. Cold formed purlins are made of high-strength steel. Cold formed Z and C are the workhorses of the industry. It can be designed as a continuous or simple-span member. Therefore it can be made continuous by overlapping and fastening. The Wind forces are acting normally on buildings and assume to act normal to the roof truss and the gravity loads passes through the centre of gravity of the purlin section. When the purlins are simply supported at the rigid frame rafters or trusses, the maximum bending moment will be $\frac{wl^2}{8}$ about each axis where 'w' is the appropriate component of the load. Although, if sag rods are used it will provide lateral supports in Y-axis bending, requiring the purlins be treated as continuous beams and then maximum bending moment will be $\frac{wl^2}{10}$

II. METHODOLOGY

A. Dimension of Z Purlin

Specifications	Symbol	Z(mm)
Overall depth	d	200
Width of flange	b	60
Length of lip	c	20
Thickness of member	t	1.5
Inner radius of curvature	r	4
Length of purlin	L	20



The test specimen of Z sections are shown in Fig. 2 to Fig 5

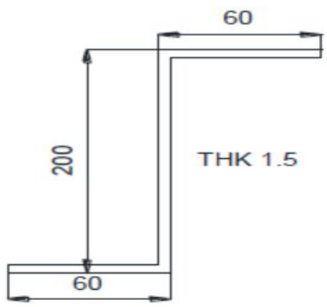


Fig. 2 Section properties of Z purlin without lip

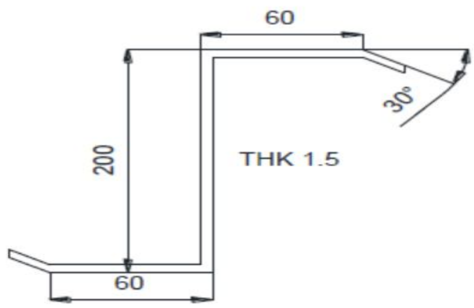


Fig. 3 Section properties of Z purlin with 30° lip

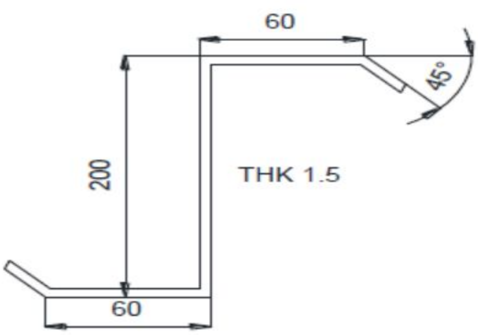


Fig. 4 Section properties of Z purlin with 45° lip

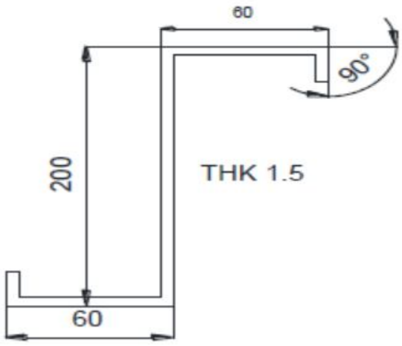


Fig. 5 Section properties of Z purlin with 90° lip

B. Material Properties of Cold-formed Steel

Table 1 Property of Cold-Formed Steel

COLD-FORMED STEEL NON-LINEAR	
DENSITY	7850 kg/m^3
ISOTROPIC ELASTICITY	
DERIVE FROM	Young's modulus
YOUNGS MODULUS	2.00E+11 Pa
POISSIONS RATIO	0.3
BULK MODULUS	1.67E+11 Pa
SHEAR MODULUS	7.69E+10 Pa
BILINIEAR ISOTROPIC HARDENING	
YIELD STRENGTH	3.45E+08 Pa
TANGENT MODULUS	1.45E+09 Pa

Table 2 Specimens details

Specimen(mm)	Dimension(mm)	Length(mm)
Z-section without lips (Z1)	200x60x20x1.5	8000
Z-section with 30º lips (Z2)	200x60x20x1.5	8000
Z-section with 45º lips (Z3)	200x60x20x1.5	8000
Z-section with 90º lips (Z4)	200x60x20x1.5	8000

III. FINITE ELEMENT MODELLING

The finite element methodology is a numerical analysis technique for getting approximate solutions to a wide selection of engineering issues. Most of the engineering issues these days create it necessary to get approximate numerical answer to issues instead of precise closed kind solutions. ANSYS will perform advanced engineering analyses quickly, safely and much by its sort of contact algorithms, time based mostly loading options and nonlinear material models. The basic plans behind the finite vary of parts having finite dimensions and reducing the structure having infinite degrees of freedom to finite degrees of freedom. Then the initial structure is that the assemblage of those components connected at a finite component analysis a complicated software system of ANSYS R.15 was used. The elastic properties of material were appointed to make a model cold formed steel Z section with and without lips.

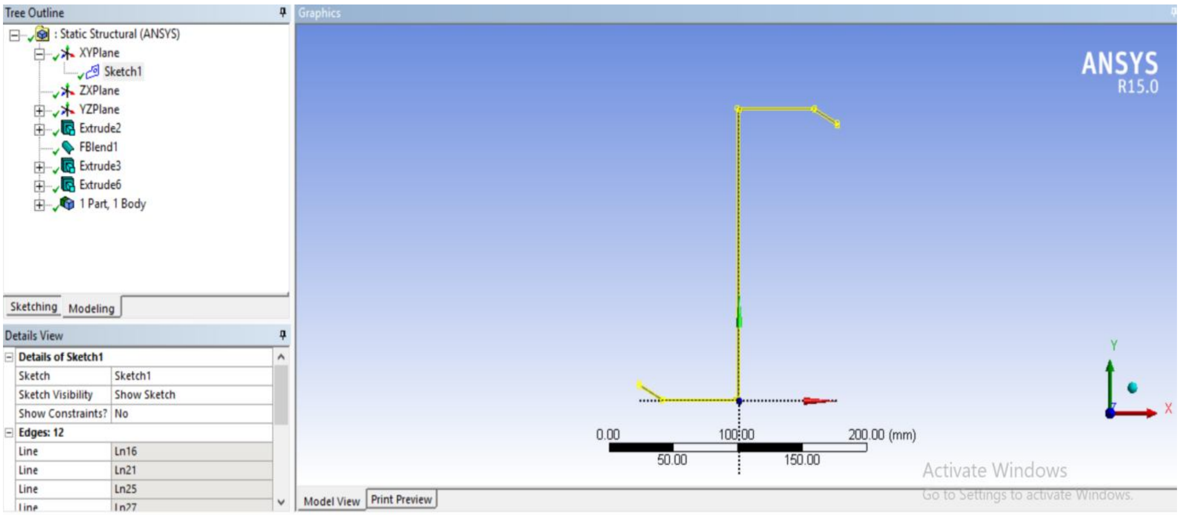


Figure 6 2-dimensiosnal Z purlin

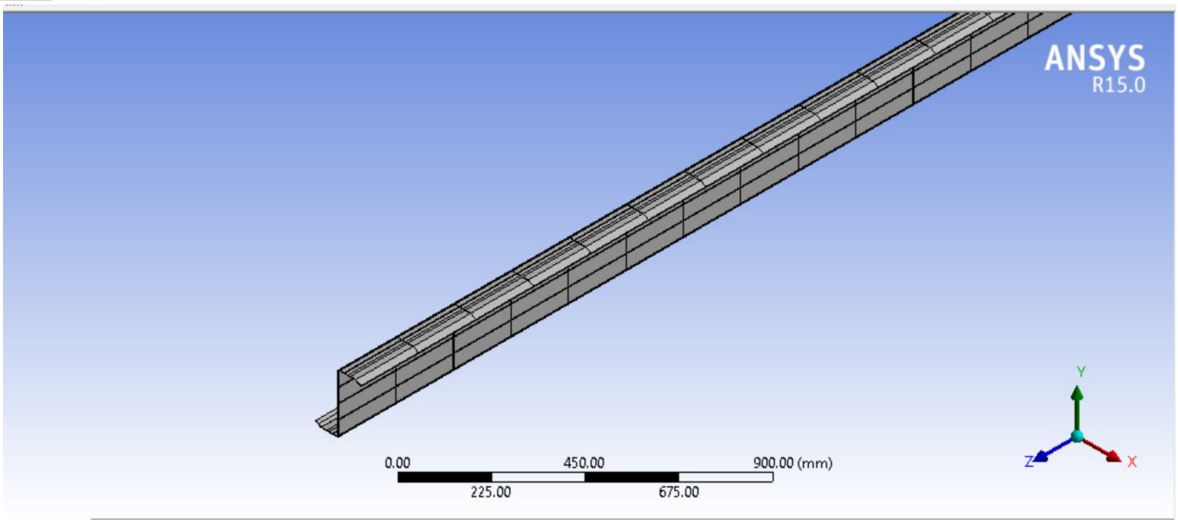


Figure 7 Typical Meshed model of Z purlin

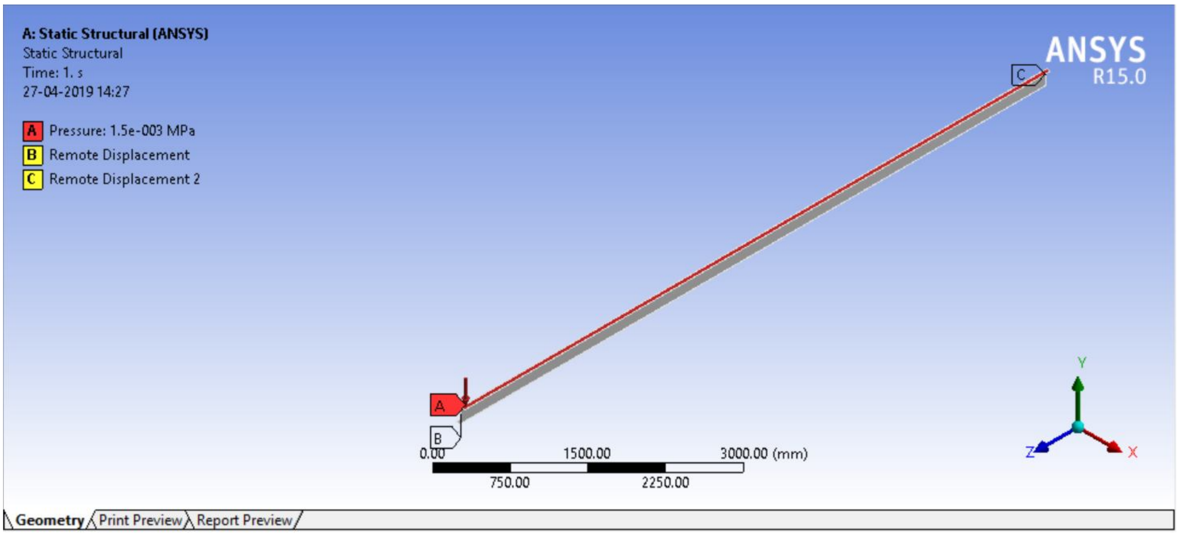


Figure 8 Boundary conditions and load application

IV. RESULT AND DISCUSSIONS

The analysis of the purlin is done by using the software ANSYS R15.0.By applying boundary conditions and loads the results are calculated. The results are discussed in the form of deflection. The systematic results of Cold-formed Z purlin with lips and without lips are discussed and results were discussed.

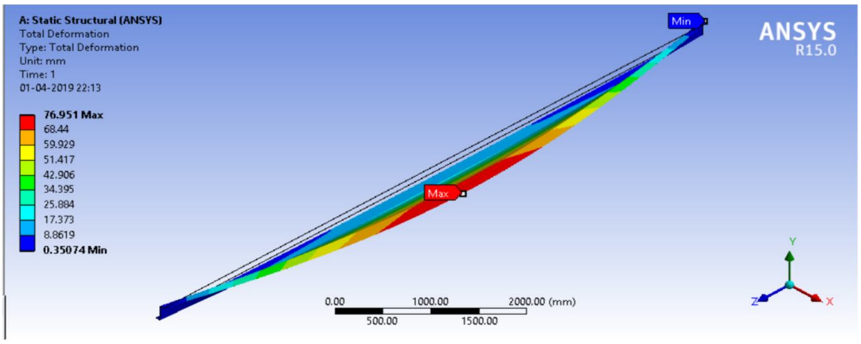


Figure 9 Deflection of Z purlin without lips

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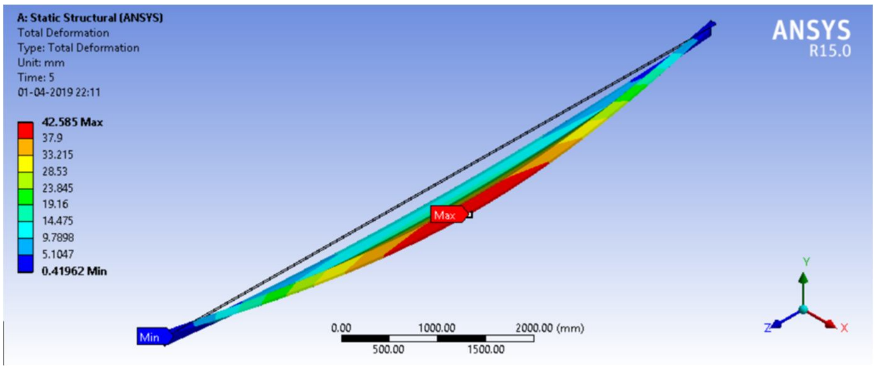

Figure 10 Deflection of Z purlin with 30⁰ lips

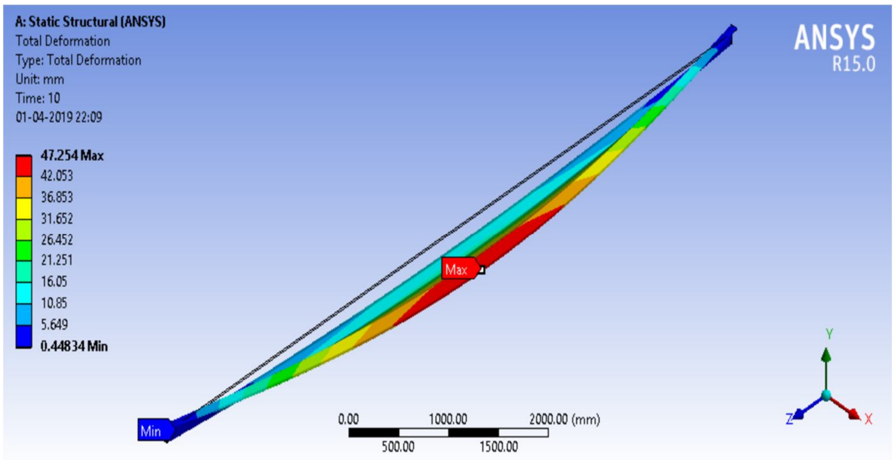

Figure 11 Deflection of Z purlin with 45⁰ lips

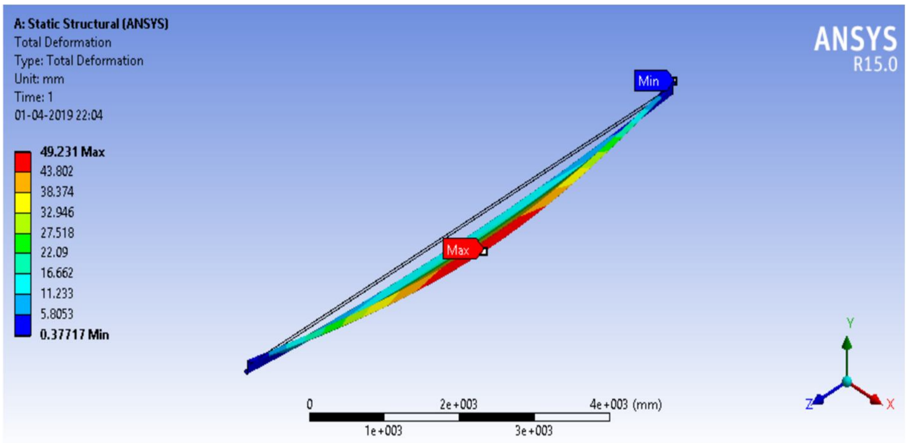

Figure 12 Deflection of Z purlin with 90⁰ lips

Table 3 Maximum Deformation

Specimen	Total Deformation (mm)
Z1	76.95
Z2	42.58
Z3	47.25
Z4	49.23

The deformation of the purlin with lips and without lips is shown in table no. 3.The maximum allowable limit of deformation is checked by referring IS Codes like IS800;2007, BS5950-5: 1998. The deformation of purlin without lips is 76.95mm which is maximum among all. The deformation of purlin with 30 lips is 42.58mm which is least among all.

V. CONCLUSION

Comparative studies on Cold-formed Z purlin with lips and without lips are made and the following conclusions were made.

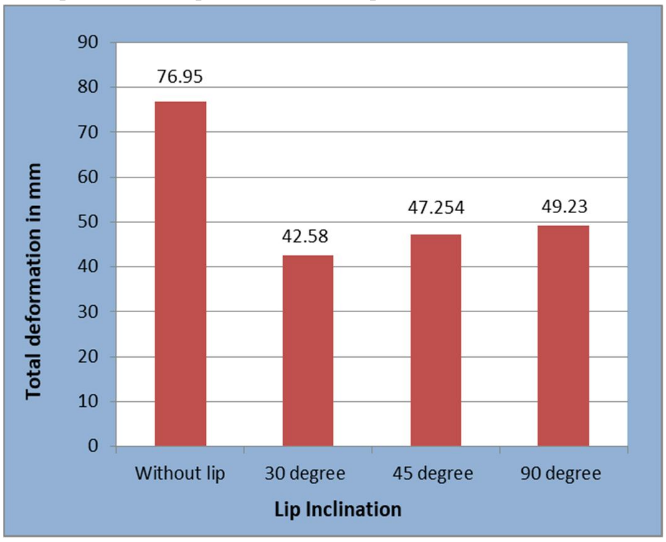

Figure 13 Total deformations vs. lip inclination

A. The ultimate deformation of Cold-formed Z purlin without lips is maximum whereas the ultimate deformation of Cold-formed Z purlin with 30^{o} lips is minimum.
B. The Cold-formed Z purlin with 30^{o} lips is more desirable due to its minimum deformation.
C. Cold-formed Z purlin with 45^{o} lips is adopted because the overlapping of the purlins can be done easily.
D. The lips provided in the section to reduce the deflection of the member.

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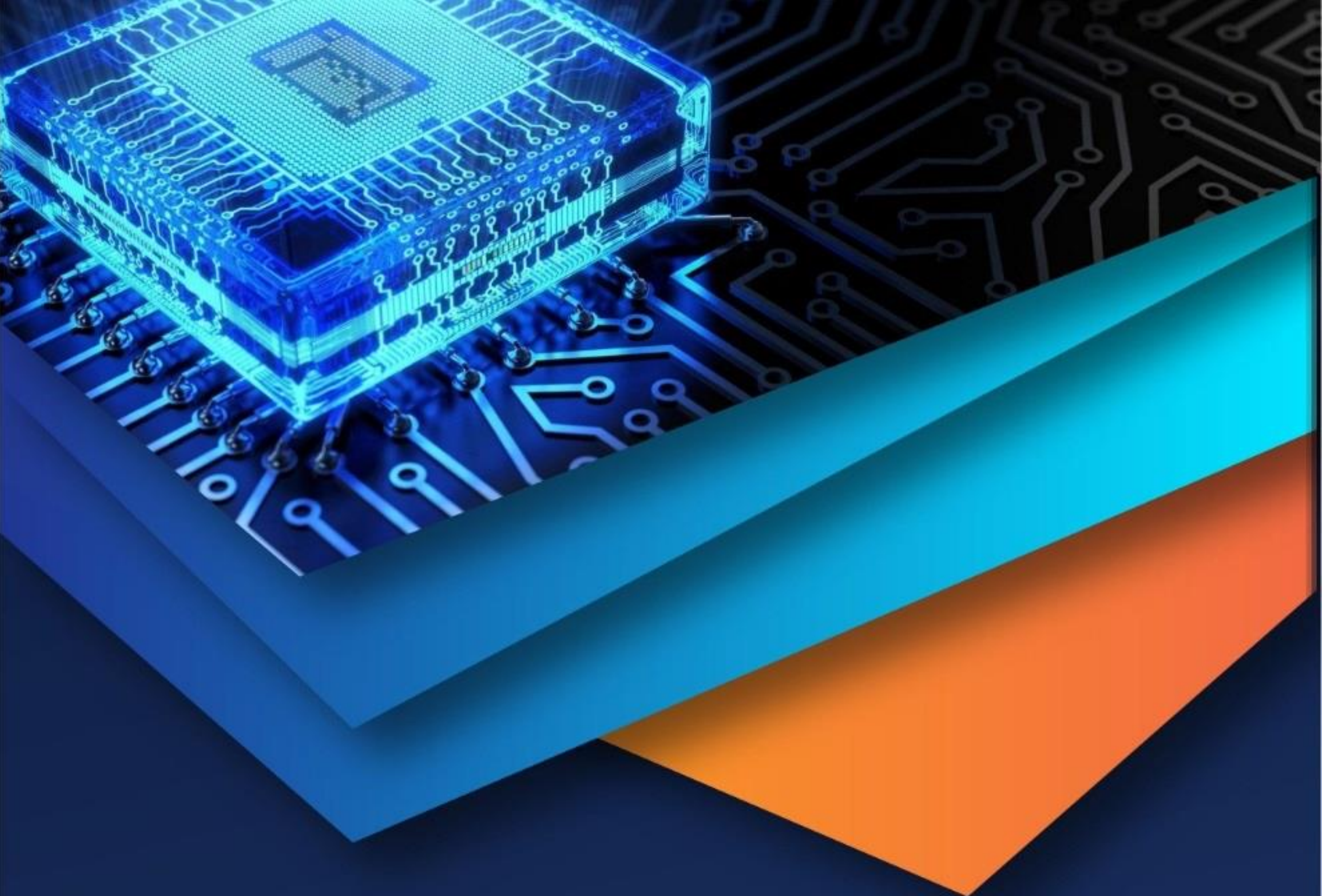

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