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STATIC STRUCTURAL ANALYSIS OF 3 AXIS CNC MACHINE TABLE USING FINITE ELEMENT ANALYSIS

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ABSRACT

A machine table is the component which holds and supports the work piece. To obtain a good finished and accurate work piece on a 3 axis CNC machine, a table should be sufficient rigid and must have good mechanical properties. A finite element analysis gives a systematic study of failure criterion which helps for further development of the 3 axis machine tables. In this paper, Static Analysis is performed on machine table to find out stresses generated in table, deformation of the table due to its weight. The finite element analysis is performed by making 3D geometry in CATIA software and analyse by using ANSYS software.

Keywords: Cast Iron, Deformation, FEM, Machine Table, Static Structural

I. INTRODUCTION

3 axis CNC machine table is the rectangular casting located on the base which supports the fixtures & the work piece while machining. The table rest on ways on the saddle. The top of the table is accurately finished and T-slots are provided for clamping the work and other fixtures on it. The table fixed on machine structure receives vertical forces of work piece and fixtures.

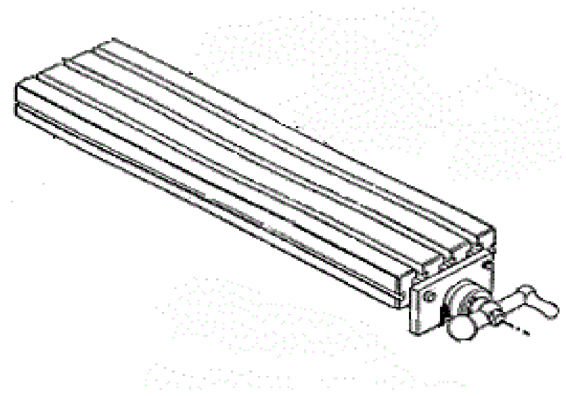

Fig. 1.1 CNC machine table

In the past few decades, the finite Element Analysis (FEM) has been developed for the modelling and simulation of various engineering systems. The basic idea in the FEM is to find out the solution of complicated problems with relatively easy way. Finite element method is a numerical method used to solve physical problems governed by a differential equation. In the Finite Element Method, the solution generated by analysing many small sub regions called Finite elements.

The C. C. Hong et al. [1] worked on great five axis turning-milling complex CNC machine. The paper provides information of computer aided engineering (CAE) for industries. They have performed analysis on secondary and primary shaft system, machinery bed with respect to static construction, stresses & deformation. By using various boundary conditions they found out maximum displacement values for machinery bed and they state that the external load value below 10Mpa is safe for machinery bed. Also they got the results for reducing weight of CNC machine and maintain good stress to resist external load.

The B. Malleswara et.al [2] presents their paper on modelling and analysis of milling machine bed for reducing weight of machine bed by its dynamic and static analysis. They made modelling of machine bed in CATIA and after analyse by using ANSYS with boundary conditions. They take three material grades of cast iron G15, G40 and G70. They conclude that the G 15 material is better due to its mechanical and vibrational characteristics.

The B. V. Subrahmanyam et al. [3] have performed static and dynamic analysis on three types of machine structure i.e. milling machine, shaping machine, lathe machine. In ANSYS they fixed the base of machine and the load on machine is considered as machine's self-weight. They conclude that the stresses generated in lathe machine structure is more than other two, also they conclude that as the natural frequencies increases the deformation gets increases.

The Sujeet Ganesh Kore et al. [4] worked on use of bionic structure in machine tool design. The main aim the study is to optimization of machine structure using bionic structure design. In the paper they analyse two types of structures i.e. existing bed model and optimized bed model by using CI and structural steel as a material. They succeed to make an optimized model which has low weight and good mechanical properties.

The B. Li et al. [5] worked for optimization machine tool bed with weight distribution consideration. In this paper they took the bed structure of grinding machine for optimization. They prepared the spring model of the bed which consists of stiffener plates for analysis purpose. From this study they conclude that the method of finite element analysis can be easily employed to find load bearing topology for reduction of the weight of machine bed.

The auther S. D. Kamble et al. [6] have made their paper on the frame analysis of EDM machine tool. They assembled the machine using 3D modelling software CATIA and analysis is done by using ANSYS. In this paper they take four channel thicknesses designs having thickness 6mm, 5mm, 4mm, 3 mm. After analysing they found that the maximum stress is acts at centre of machine table, the 5 mm channel thickness design have more deformation and the 3 mm channel design gives good acceptance value and weight reduction.

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II. METHODOLOGY

The methodology is subdivided into three parts

- CAD model
- Defining materials
- Static Analysis

2.1 CAD Model

For the analysis of the machine table, firstly the CAD model of the table is created by using CATIA V5 software. The dimensions which are taken for the table are given below.

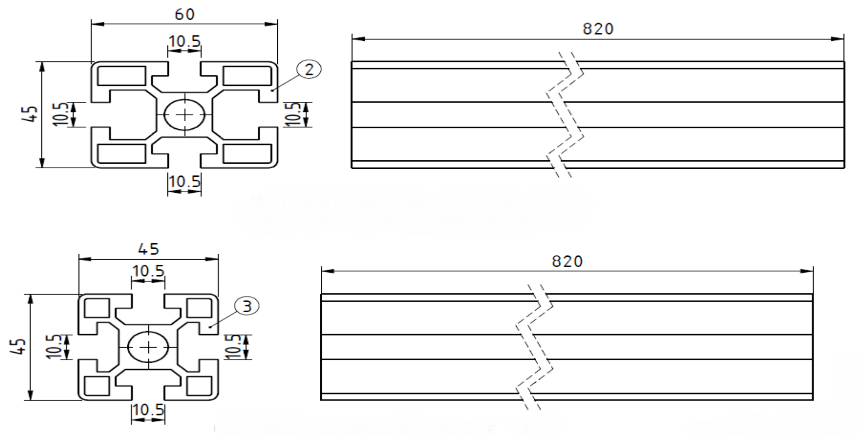

Fig. 2.1 Dimensions of CNC Machine Table

The 3D modelling of machine table is done by using Part Design and Assembly Design workbenches. The modelled machine table by using CATIA V5 is shown in Fig. 2.2.

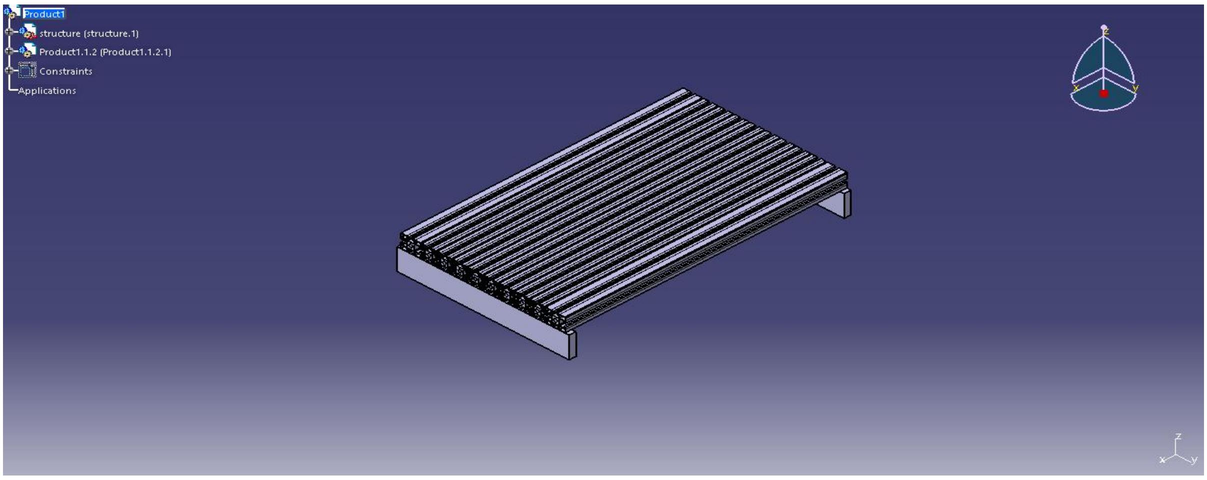

Fig. 2.2 Machine Table Model

2.2 Materials and its properties

The material used for the machine table is grey cast iron. In this paper, for the analysis purpose three materials are used i.e. ASTM grade 20 (ISO grade 150, EN-JL 1020) grey cast iron, ASTM grade 30 (ISO grade 200, EN-JL 1030) grey cast iron and ASTM grade 50 (ISO grade 350, EN-JL 1060) grey cast iron. The properties of the above grades are given in below table.

Table No. 2.1 Properties of grey cast iron grade

Material Properties	Grade 20	Grade 30	Grade 50
Density	7.2 g/cm^3	7.2 g/cm^3	7.2g/cm^3
Young's Modulus	82 Gpa	100 Gpa	140 Gpa
Poisson's Ratio	0.26	0.26	0.26
Tensile strength: Ultimate	150 Mpa	220 Mpa	380 Mpa
Compressive Strength: Ultimate	570 Mpa	750 Mpa	1130 Mpa

2.3 Static Analysis

A static analysis gives a result when the forces acting on structure at rest position. From the static analysis we can find out deformations of the structure, stresses generated in the structures and failure modes of the machines at rest condition. For the analysis, Mesh generation is an important phenomenon. After the importing the CAD model in ANSYS the important step is to mesh that model. For 3 axis CNC machine table the mesh is generated with fine relevance centre by using mesh tab. After solving the meshing process the total elements generated is 60664 and the number of nodes is 351522.

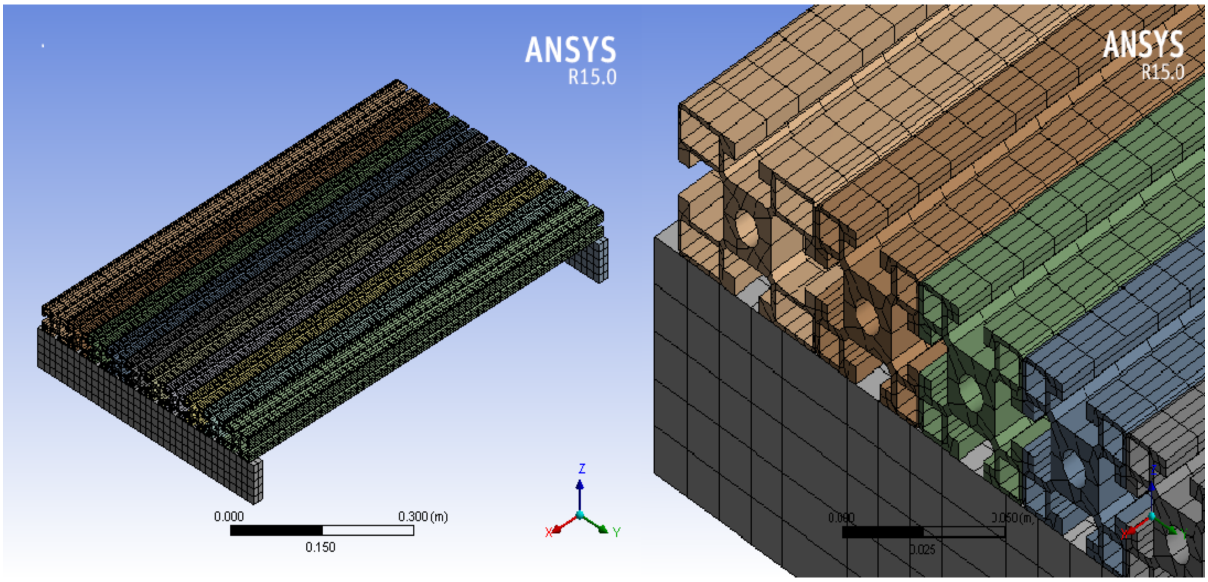

Fig. 2.3 Meshing of machine table

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The boundary conditions used for all three grades are, the legs of the machine table if fixed i.e. the all degrees of freedom of the legs are becomes zero. The load acting on the machine table is its self-weight which is generated by standard earth gravity.

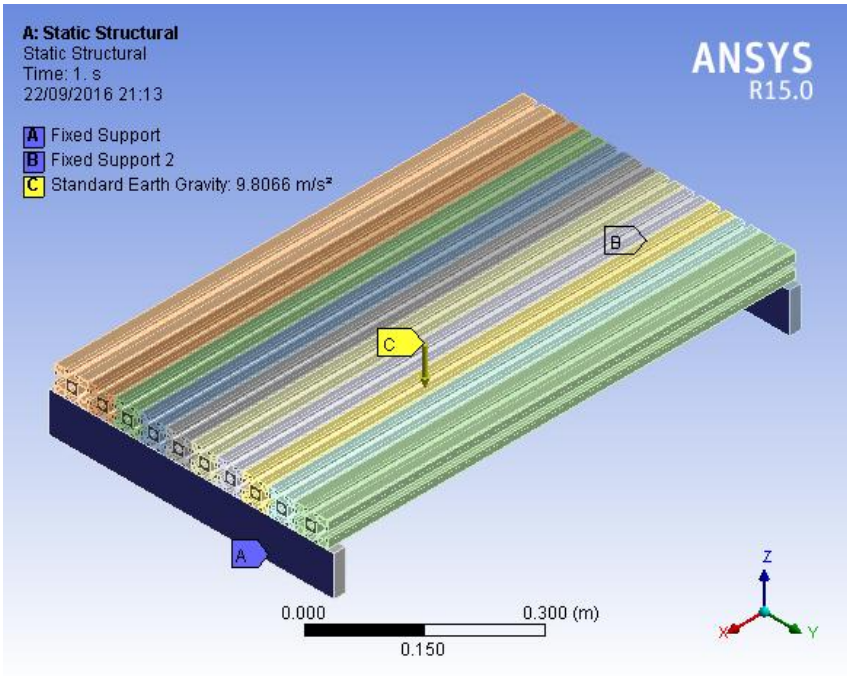
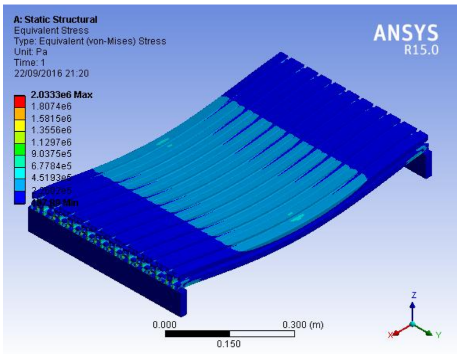
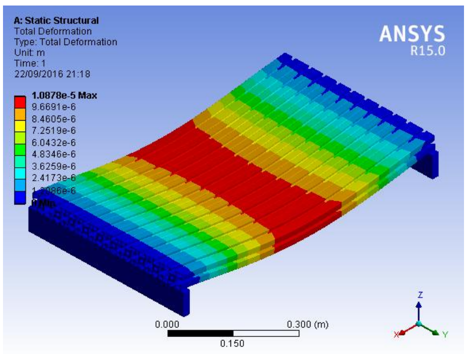


Fig. 2.4 Boundary conditions for static analysis

Using above boundary conditions, the equivalent stress (von-mises stresses) and total deformation is found out for every grade of cast iron. The results find out by using static structural analysis is given in below table.

Table No. 2.1 Von-mises stress, Total Deformation of table

Grade	Von-mises stresses	Total deformation
ASTM Grade 20		

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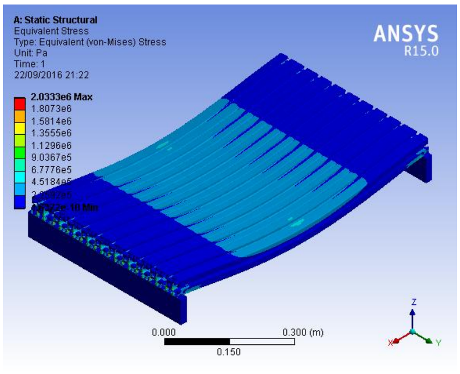
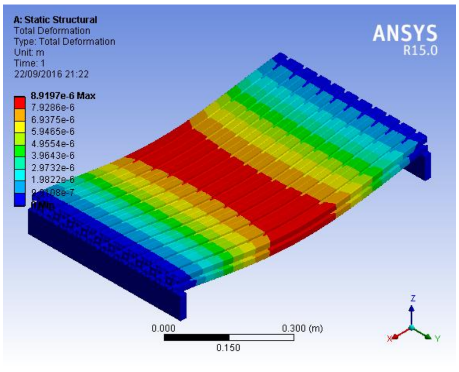
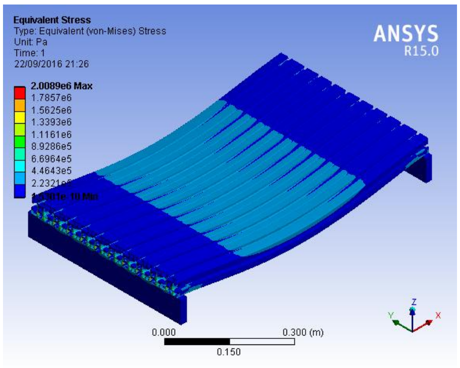
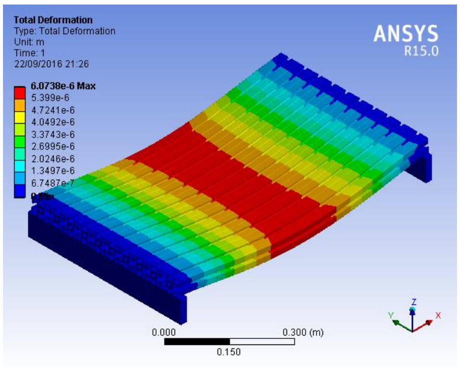
ASTM Grade 30





ASTM Grade 50





III. RESULTS AND DISCUSSIONS

The results show that the maximum deformation due to self-weight is at centre of the table. The deformation of grade 50 material is less than other two grades. The results are compared in tabular data for the three grades of cast ironare given below.

Table No. 3.1 Static analysis results

	Vonmises Stress	Total Deformation
G 20	2.0333MPa	0.010878mm
G 30	2.0333MPa	0.0089197mm
G 50	2.0089MPa	0.0060738mm

IV. CONCLUSION

From this paper we conclude that the deformation of Grade 50 material is 44.16% less than Grade 20 and 31.91% is less than Grade 30 material. The equivalent stress generated in the Grade 50 is less than other two materials. From these results it is observed that the Grade 50 material is best suited for the machine table in static loading because of its material properties and less deformation.

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