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# Stability Analysis of Gravity Dam by Using STAAD Pro in Time History Method

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***Abstract:***
***Gravity dams are strong solid structures that keep up their dependability against configuration loads from the geometric shape, mass and quality of the solid. The motivations behind dam development may incorporate route, surge harm decrease, hydroelectric power era, fish and untamed life improvement, water quality, water supply. The outline and assessment of solid gravity dam for seismic tremor stacking must be founded on fitting criteria that reflect both the coveted level of wellbeing and the decision of the plan and assessment techniques. The Dam talked about in this paper is of the stature 130m for which Equivalent static investigation and element examination by utilizing time history strategy is done. The vast majority of the associations break down the dams by flexible strategy which gives unpleasant outcomes. Here Finite Element Approach is utilized to investigate the dam which is ended up being the sensible for such structures. An examination is done between the identical static methodologies of seismic investigation with element examination by utilizing time history.***

*Keywords:* ***Gravity Dam, Finite element analysis, Dynamic analysis, Stress Contours, Staad-pro***

## INTRODUCTION

Any structure that is constructed will undergo many forces such as wind, seismic, self-weight or forces like ice/snow etc. Among these, seismic forces are natural and as we know earthquake is a natural calamity and is so unpredictable. in order to prevent the structure from being collapse, it's very important to adopt earthquake resistant design philosophy while designing the structure. A wave which arises during Seismic event carries very massive speed and when it struck with any structure it travels through foundation to the top roof resulting In-elastic deformation. there may be the possibility of collapse of whole structure or probably it will survive depending upon the design adopted but surely the structure will have some major repairing and strengthening works which will be costly.

Sometimes damages caused by earthquake vibrations are very high that goes beyond repair works. Generally hydraulic structures like concrete gravity dam, canals and RCC multi-storied. Structures are sufficiently stiff and ductile. These structures undergo large Deformations in its inelastic region. Concrete gravity dam is a massive structure having many forces acting on it. It's very important for the dam to survive against seismic vibrations. This paper is mainly focused on behavior of concrete gravity dam with nonlinear characteristics using seismic time history analysis. In order to study the precise behavior of structures, seismic time History or response spectrum plays an important role. These analyses methods can be adopted to study the structures having single degree of system or multi degree of freedom system possessing non-linear characteristics. Time history performs analysis which is based on Time-acceleration as an input data which is basically an already experienced acceleration w.r.t time by the ground during seismic event. Time history analysis provides the most probable shapes and directions of structure which is its dynamic structural response under loading which varies as according to specified time-acceleration

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function. One can predict either the structure will survive or not against these seismic vibrations by using time history analysis results. A mainly structure consists of stiffness and damping as a nonlinear parameter. Damping mostly encountered in dynamic problems related with structural control, aerodynamics and offshore hydraulic structures. Most hydraulic structures undergo yielding under seismic vibrations.

Damping or inertia, displacement and acceleration are non-linear parameters which provide the non-linear characteristics to the structure. The design lateral force shall be considered in each of two orthogonal horizontal directions of the structure. For structures which have the lateral force resisting elements in the two orthogonal directions, the design lateral force shall be considered along one direction at a time, and not in both directions simultaneously. It is known that for most world tectonic regions the ground motion can act along any horizontal direction, therefore, this implies the existence of a possible different direction of seismic incidence that would lead to an increase of structural response. Critical angles are earthquake incidence angles, producing critical responses.

In this study, a four storey reinforced concrete building with moment resisting frame, of different shapes i.e., L shaped and Shaped are analyzed by Time history method of Dynamic analysis of Earthquake. A set of values from 0 to 90 degrees, with an increment of 10 degrees has been used of excitation of seismic force. The details of the study and its result are described briefly in the following section of the paper.

Features of the concrete gravity dam Concrete gravity dam is a solid structure which is made up of concrete or masonry. It acts as a water retaining structure and holds a large amount of water by creating a reservoir on its upstream side. That's why gravity dam is constructed across a river for retaining of water. The cross section of the gravity dams approximately triangular in shape and having an apex at top and maximum width at bottom. There are various forces acting on the gravity dam mainly hydrostatic pressure, silt pressure, wave pressure, ice pressure, wind forces, self-weight of the dam, uplift pressure and seismic forces etc. The section of the dam is designed in such a way that it would resist all these forces acting on it from various directions under the effect of its own self weight. Gravity dams are also called as solid gravity dams because they are rigid as well as solids and no bending stresses are induced at any point on a dam structure. They are generally straight in plan .the upstream face is vertical and slope of downstream face is 0.7:1.For construction, they need good foundations and topography to perform better throughout in its lifetime.

**About the software:**

STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, A.

In late 2005, Research Engineer International was bought by Bentley Systems. An older version called Staad-III for windows is used by Iowa State University for educational purposes for civil and structural engineers. The commercial version STAAD.Pro is one of the most widely used structural analysis and design software. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

## 4. Finite Element Modeling of The Dam

The dam body is modeled in STAADpro using the SOLIDisoparametric finite elements with eight nodes.

Each node has three translational degrees of freedom. The stiffness matrix of the solid element is evaluated by numerical integration with eight Gauss – Legendre points. The dam is analyzed for several basic loads and load combinations possibly met with during its service. These are enlisted in table 1 below. The stresses induced are checked for all the combinations and the dimensions are so framed that the factor of

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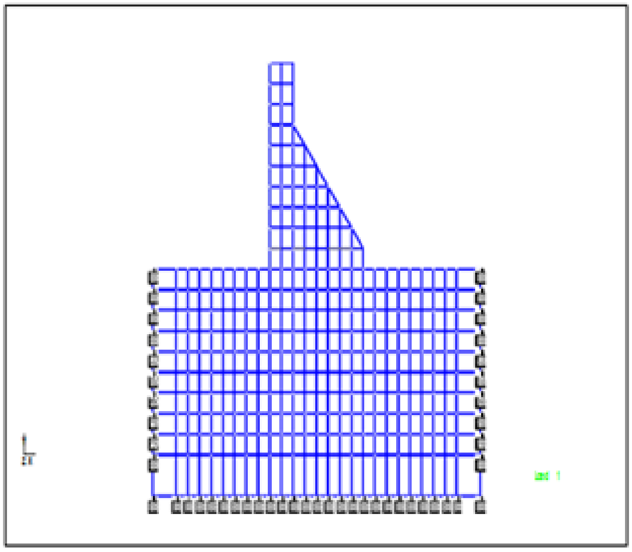
safety mentioned above is maintained. The base of the dam is to rest on rock and the extra excavation into be filled with concrete of same strength, the foundation rock of approximately equal to the height of dam is modeled around and below the foundation level. The Young's modulus for concrete is used as 2.26 x 104 N/mm2 and density 25 ken/m3.For the foundation rock these properties were 1.0 x 104 N/mm2 and 28.8 kN/m3 respectively. Poisons ratio for concrete is 0.17whereas for rock it is 0.16.



Figurel: Finite element modeling of the dam

## METHODOLOGY

The present study undertaken deals with time history method of dynamic analysis. Time history is available only for X direction, so in order to apply forces in different angles, the structure has to be rotated with incidence angle from 0 to 90 degrees, with an increment of 10 degrees and column forces have been investigated in all cases. Further in order to find the accurate angle the interval of one degree is used. The columns have been divided into three main categories, including corner, side and internal (middle) columns and the results are compared.

## RESULTS AND DISCUSSION

### L Structure Time History Method

### Table No. 2 a: L Structure Corner Column C1

| ANGLE | SHEAR+ | SHEAR- | My | Mz |
|---|---|---|---|---|
| 0 | 801 | 86.4 | 23.2 | 57 |
| 10 | 797 | 87 | 25.4 | 56 |
| 20 | 797 | 91 | 27.5 | 55 |
| 30 | 798 | 91.5 | 30.15 | 53.12 |
| 40 | 794 | 87.01 | 34.12 | 49.15 |
| 50 | 786 | 80.14 | 37.01 | 45.12 |
| 60 | 775 | 71.4 | 38.41 | 41.45 |
| 70 | 768 | 60.5 | 39.01 | 37.12 |
| 80 | 768.003 | 52.4 | 37.45 | 32 |
| 90 | 768 | 53.5 | 39.41 | 31.058 |

### Table No. 2 B: L Structure Side Column C2

| ANGLE | SHEAR + | SHEAR - | My | Mz |
|---|---|---|---|---|
| 0 | 1313 | 0.4 | 34.01 | 78.704 |
| 10 | 1313 | 13 | 34.21 | 73.078 |
| 20 | 1313 | 24.5 | 38.12 | 71.051 |
| 30 | 1313 | 36.5 | 42 | 69.234 |
| 40 | 1284 | 50.1 | 47.3 | 62 |
| 50 | 1275 | 65.4 | 52.1 | 63 |
| 60 | 1254 | 72.41 | 54.51 | 61 |
| 70 | 1234 | 77.24 | 56.41 | 54 |
| 80 | 1224 | 79.54 | 57.25 | 53 |
| 90 | 1224 | 80 | 58 | 49 |

### TABLE NO 3: T STRCTURE COLUMN CORNER C1

| ANGLE | SHEAR | SHEAR | My | Mz |
|---|---|---|---|---|
| 0 | 831.51 | 84 | 24 | 59 |
| 10 | 837 | 88 | 31 | 60.148 |
| 20 | 841 | 91 | 32 | 60.15 |
| 30 | 841 | 92 | 30.01 | 58 |
| 40 | 835 | 89 | 33 | 54 |
| 50 | 826 | 80.14 | 35 | 48 |
| 60 | 814 | 69.14 | 36.018 | 45.12 |
| 70 | 802.5 | 58.12 | 36.501 | 39.12 |
| 80 | 796 | 50.12 | 37 | 34.12 |
| 90 | 794.029 | 51.02 | 37 | 31.54 |

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**Table No. 3 B: T STRUCTURE SIDE COLUMN C2 AND C3**

| ANGLE | SHEAR + | SHEAR - | My | Mz |
|---|---|---|---|---|
| 0 | 1193 | 2.181 | 40.12 | 59 |
| 10 | 1204 | 5.7 | 41.02 | 57.41 |
| 20 | 1214 | 9.1 | 45.41 | 54.5 |
| 30 | 1225 | 13.81 | 47.12 | 51.25 |
| 40 | 1241 | 18.61 | 49.41 | 45.1 |
| 50 | 1253 | 24.12 | 50.12 | 38 |
| 60 | 1262 | 27.12 | 53 | 32.01 |
| 70 | 1267 | 46.12 | 54.12 | 23.602 |
| 80 | 1264 | 67.14 | 55.12 | 13.89 |
| 90 | 1264 | 77 | 54.4 | 2.218 |

| ANGLE | SHEAR + | SHEAR - | My | Mz |
|---|---|---|---|---|
| 0 | 1754 | 42 | 13 | 83.025 |
| 10 | 1764 | 45.41 | 21.01 | 82.402 |
| 20 | 1762 | 48.41 | 38.01 | 77.312 |
| 30 | 1768 | 49 | 47.12 | 70.015 |
| 40 | 1768 | 47 | 47.95 | 65.379 |
| 50 | 1757 | 43 | 42.15 | 53.141 |

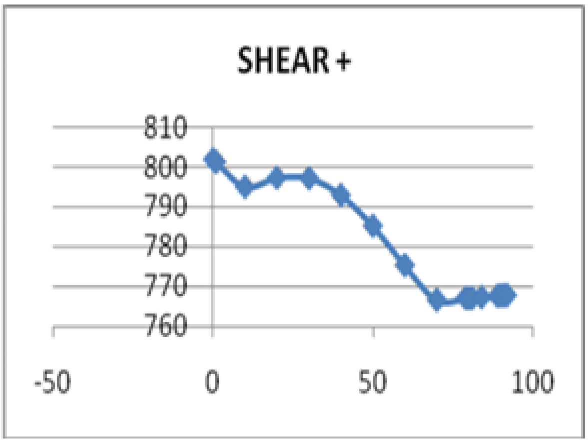


Figure No. 3 a: Graph of Fx v/s Angle of Rotation in degrees

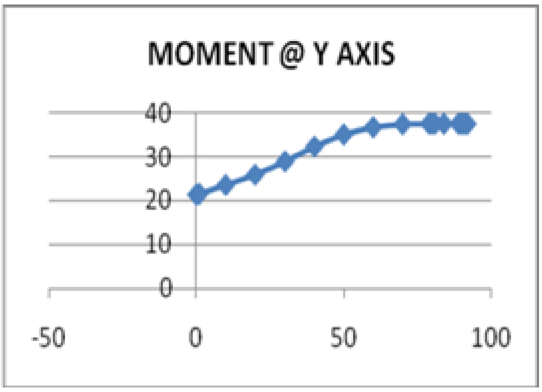


Figure No. 3 b: Graph of My v/s Angle of Rotation in degrees

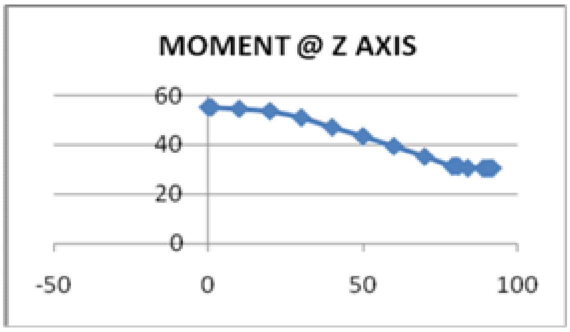


Figure No. 3 c: Graph of Mzv/s Angle of Rotation in degrees

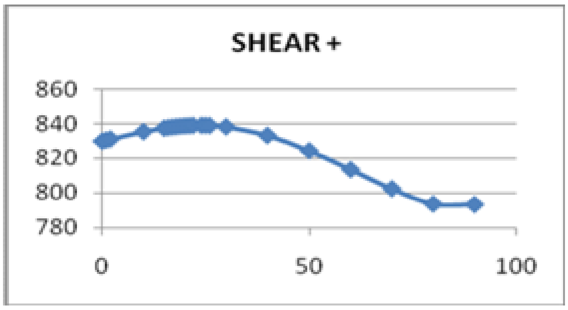


Figure No. 4 a: Graph of Fx v/s Angle of Rotation in Degrees

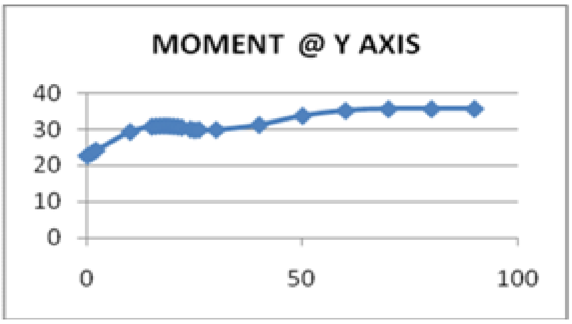


Fig No. 4 b: Graph of My v/s Angle of Rotation in degree

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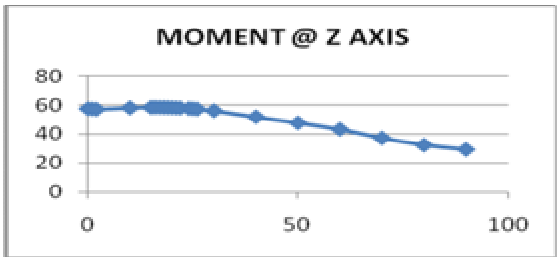


Figure No. 4 c: Graph of Mz v/s Angle of Rotation in Degrees

**L Structure Time History Method Column C2 (Side Column)**

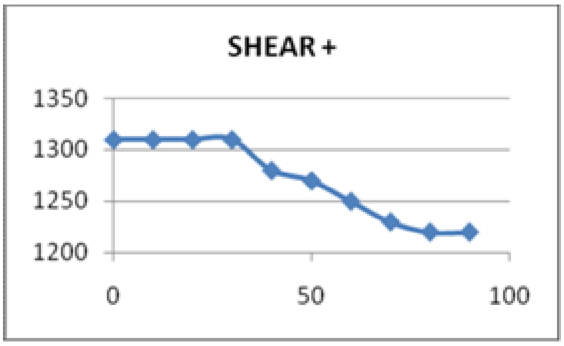


Figure No. 5 a: Graph of Fx v/s Angle of Rotation in degrees

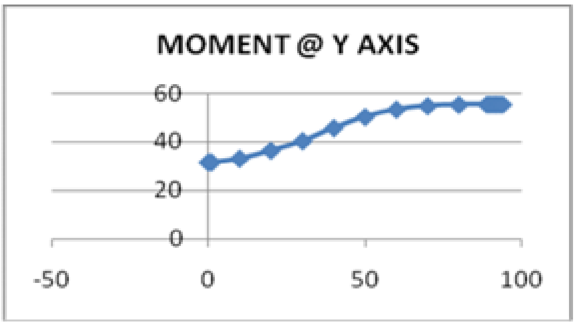


Figure No. 5 b: Graph of My v/s Angle of Rotation in degrees

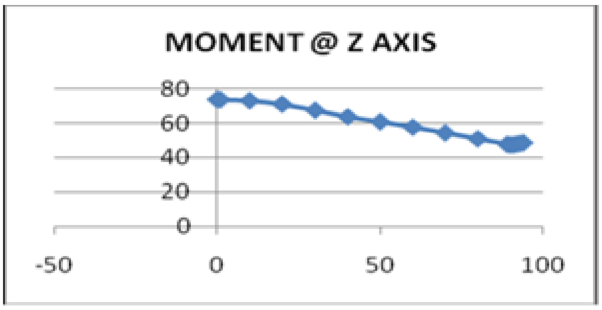


Figure No. 5 c: Graph of Mz v/s Angle of Rotation in degrees

**T Structure Time History Method Column C2 (Side Column)**

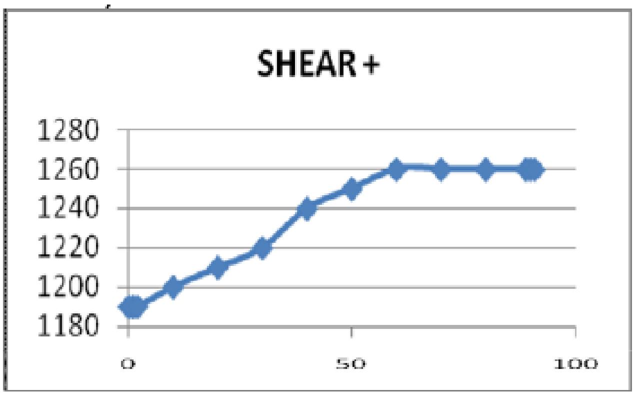


Figure No. 6 a: Graph of Fx v/s Angle of Rotation in degrees

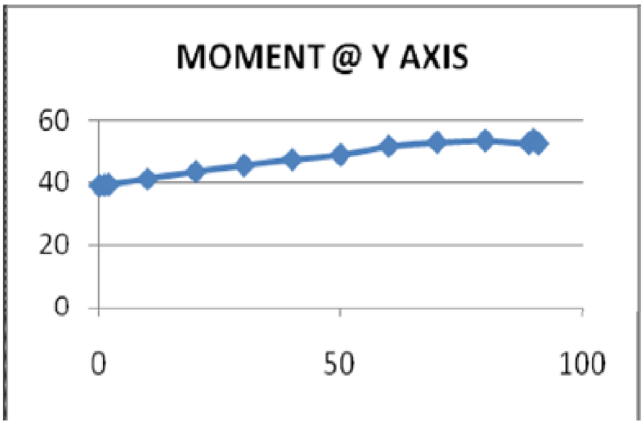


Figure No. 6 b: Graph of My v/s Angle of Rotation in degrees

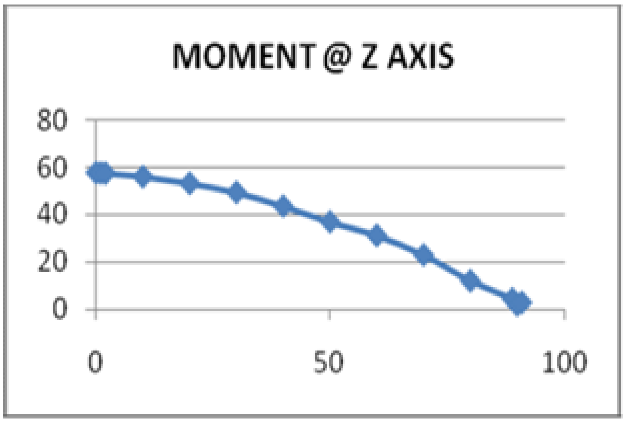


Figure No. 6 c: Graph of Mz v/s Angle of Rotation in degrees

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**L Structure Time History Method Column C3 (Middle Column)**

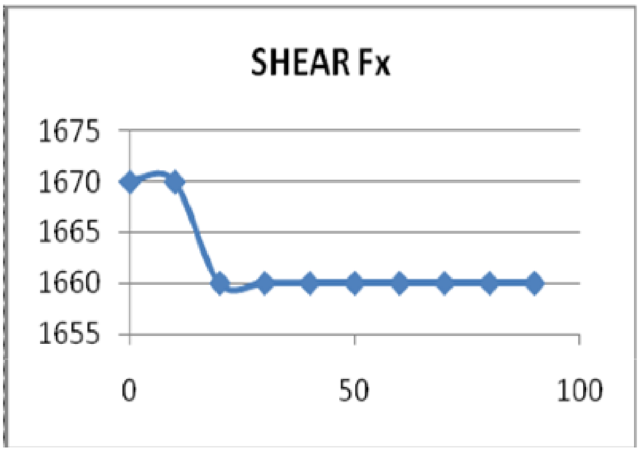


Figure No. 7 a: Graph of Fx v/s Angle of Rotation in degrees

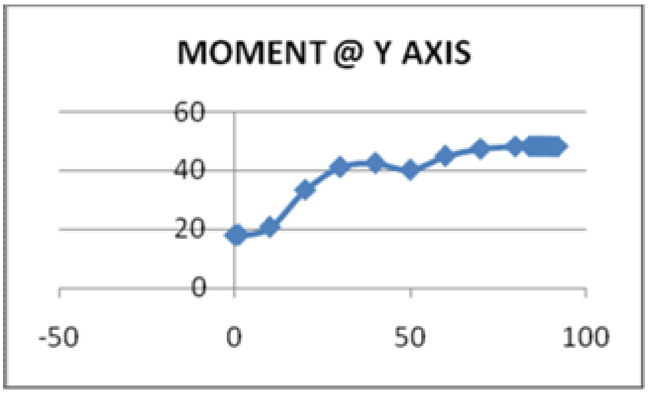


Figure No. 7 b: Graph of My v/s Angle of Rotation in degrees

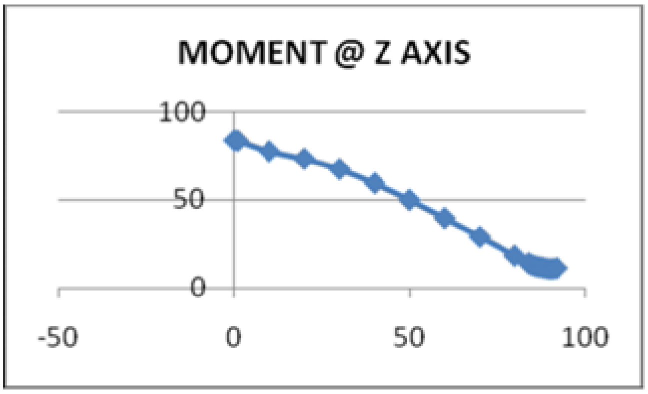


Figure No. 7 c: Graph of Mz v/s Angle of Rotation in degrees

**T Structure Time History Method Column C3 (Middle Column)**

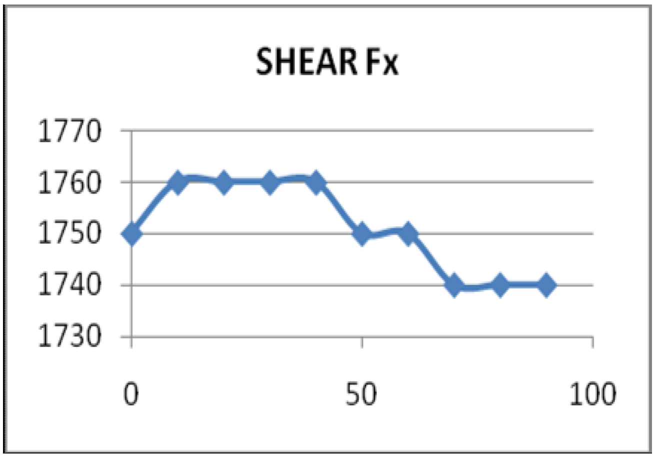


Figure No. 8 a: Graph of Fx v/s Angle of Rotation in degrees

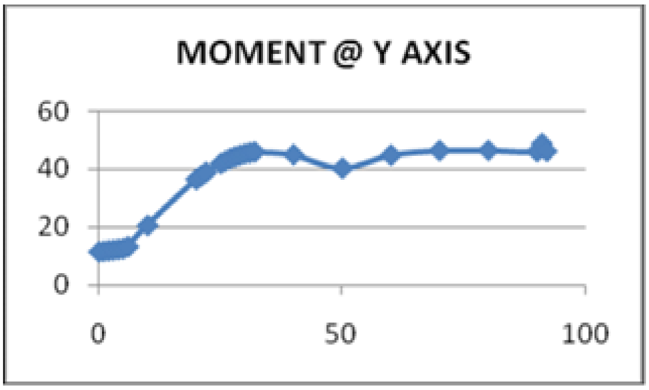


Figure No. 8 b: Graph of My v/s Angle of Rotation in degrees

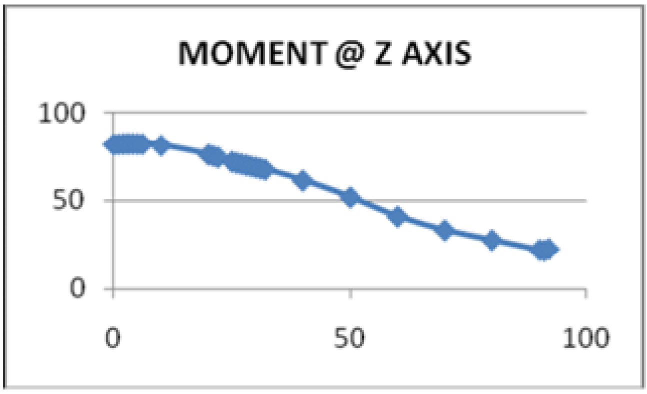


Figure No. 8 c: Graph of Mz v/s Angle of Rotation in degrees

## CONCLUSION

For Corner Column C1: The shear constrain in X course i.e. Fx is diminishing all through from zero to ninety degrees, it's most worth at zero degree for L structure while T structure moreover demonstrates explanatory diminishing bend for Fx and accomplishes most worth at twenty degrees. Minute concerning Y pivot for corner segment C1 of L structure accomplishes most worth at eighty degrees and Moment concerning Z hub achieves most at zero degrees though T structure accomplishes most worth at ninety degrees for My and for Mz at twenty degrees.

For viewpoint Column C2: Shear constrain Fx is consistent from zero to thirty degrees so it diminishes until ninety degrees for L structure while for T structure the bend is perpetually expanding i.e. least worth at zero degree and most at ninety degrees. L and T structure each accomplishes most My at ninety degrees and Mz at zero degrees. For Middle Column C3: For L structure the shear compel Fx at start will build gradually and demonstrates a lofty slant and from twenty degrees forward steady all through. T structure demonstrates a particular nature as appeared in figure No. 8a. Estimation of My i.e Moment concerning Y hub is most at ninety degrees for L structure and eighty degrees for T shaped structure.

Estimation of Mz i.e Moment concerning Z hub is most at zero degrees for L and T shaped structure.

From that point on top of charts and conclusions it will be finished that T shaped structure needs to oppose extra shear constrain than L framed structure.

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