# Structural Analysis and Design of Preheater Building in Cement Industry

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**Abstract -**The cement industry relies heavily on efficient and sustainable production processes to meet the growing demand for construction materials. The preheater, a critical structure in cement plants, plays a pivotal role in enhancing the cement production efficiency and cost-effectiveness of the overall production. This abstract outlines the essential considerations for civil structural design of a preheater building in the cement plant.The design process involves meticulous planning to ensure optimal integration of the preheater building with other structures, such as raw material proportioning hopper, rotary kiln and raw mill building. Structural stability and equipment load-bearing capacity are paramount, with attention to materials capable of withstanding the high temperatures and dynamic forces inherent in the cement manufacturing process.

Additionally, the abstract highlights opportunities for energy efficiency through waste heat recovery systems and sustainable practices. Compliance with environmental regulations, fire protection measures, and provisions for easy access and maintenance contribute to the overall robustness of the preheater building design.

In conclusion, the abstract provides a comprehensive overview of the multifaceted considerations like equipment loads, wind load effect ,structural loads in designing a preheater building in the cement industry.

***Key Words*:**Preheater,cement industry,Huge structures

## 1.INTRODUCTION

Preheater Building is one of the most vital structure of a cement plant where the raw meal is preheated using outlet hot gases of the kiln. In the dynamic landscape of cement manufacturing, the analysis and design of preheater buildings stand as a cornerstone in ensuring the efficiency, safety, and sustainability of the entire production process. These structures, housing essential preheater systems, play a pivotal role in optimizing the thermal efficiency of cement plants. The meticulous analysis and thoughtful design of preheater buildings are imperative for addressing structural stability, safety considerations and environmental compliance in the demanding context of the cement industry. Preheater is a huge mass structure which has a huge and large size structural members such as beams and column. Most of the columns overcomes huge bending moments developed in the structures. Preheater building has been designed to resist equipmental loads along with all other loadings.

## 2. Literature Review

**Viswanath K.G et al (2010**)-A study on the seismic analysis of steel-braced reinforced concrete frames was conducted. The seismic performance of reinforced concrete (RC) structures that were renovated with concentric steel bracing was examined by the author. Bracings were supplied for columns that were peripheral. The STAAD Pro programme was utilised in this work to analyse a four-story structure for seismic zone IV in accordance with IS 1893: 2002. The efficiency of several steel bracing types in the rehabilitation of a four-story structure was investigated. The impact of the steel bracing placement along the height of the RC frame on the seismic performance of the renovated structure was investigated. An assessment was conducted on the building's performance concerning global and storey drifts. It was determined what proportion of the lateral displacement was downgraded. The author came to the conclusion that the maximum inter-story drift of the frames is reduced and that the X type of steel bracing greatly increased structural rigidity.

**IS:875 (Part 1) -1987** It gives an outline of Dead Loads in the Indian Standard Code Of Practice For Design Loads (Other Than Earthquake) For Buildings and Structures. All permanent parts of the structure contribute to the dead loads, including walls, partitions, floor finishes, false ceilings, false floors, and other permanent features in the buildings. Calculating dead loads involves considering the dimensions of different components and their individual weights. The unit weight for plain concrete is around 24 KN/m3 and for reinforced concrete made with sand and gravel or crushed natural stone aggregate is also approximately 24 KN/m3.

**IS: 1893 (Part1) -2002** The Indian Standard Criteria for Earthquake Resistant Design of Structures,andcfocuses on seismic loads assessment and earthquake-resistant building design. These guidelines apply to various structures like buildings, elevated structures, industrial complexes, bridges, concrete masonry, and earth dams. Temporary features such as scaffolding and excavations are exempt from earthquake force considerations.

**ASCE 7-05** It gives us the smallest amount of load needed for building designs. Two ways to design are allowed: allowable stress design (ASD) and strength design. Designers can pick either one. Roofs usually use ASD. ASCE 7-05 has one map for wind speeds. Each building category gets an importance factor & a wind-load factor applied for final wind loads. In this version, ASD's wind-load factor is 1.0 and strength design's is 1.6. Calculate roof wind-uplift loads by multiplying ultimate wind loads by 1.0 and the right safety factor.

**Fig1:** Construction of Pre-Heater Building

## 3.BASIC MODEL REQUIREMENT METHODOLOGY

### 3.1 Site Selection

This design is prepared for load calculation of Pre-Heater Building for Asian Paint white cement plant at Al -Taween Fujairah UAE.

### 3.2 Design Philosophy

Structures design shall be carried out by Indian Standard code. The analysis and design shall be done by using STAAD PRO software. The 3D model of the structure shall be generated in STAAD**.**

### 3.3 Foundation Design Parameter

Geotechnical Investigation Report for Proposed white cement plant at Al-Taween Fujairah UAE.The allowable bearing pressure for Preheater Building. Allowable bearing pressure for has been provided in soil report as 540kN/m2 at a depth of 5.0m from ground level.

### 3.4 Equipment and Cyclonic Load

## 4.DESIGN METHODOLOGY

Discussing the different methodology carried out to create the model, calculation of the loads, analysis and design procedures, all the load calculations and the load's aspects are taken following the Indian standard code procedures for industrial structures, each segment of modeling, loading and, analysis is represented step by step in the rest of this chapter the following are the different aspects of methodology which are been covered show in flowchart.

1. Model development
2. Loadings
3. Load combinations
4. Analysis Procedure
5. Design procedure

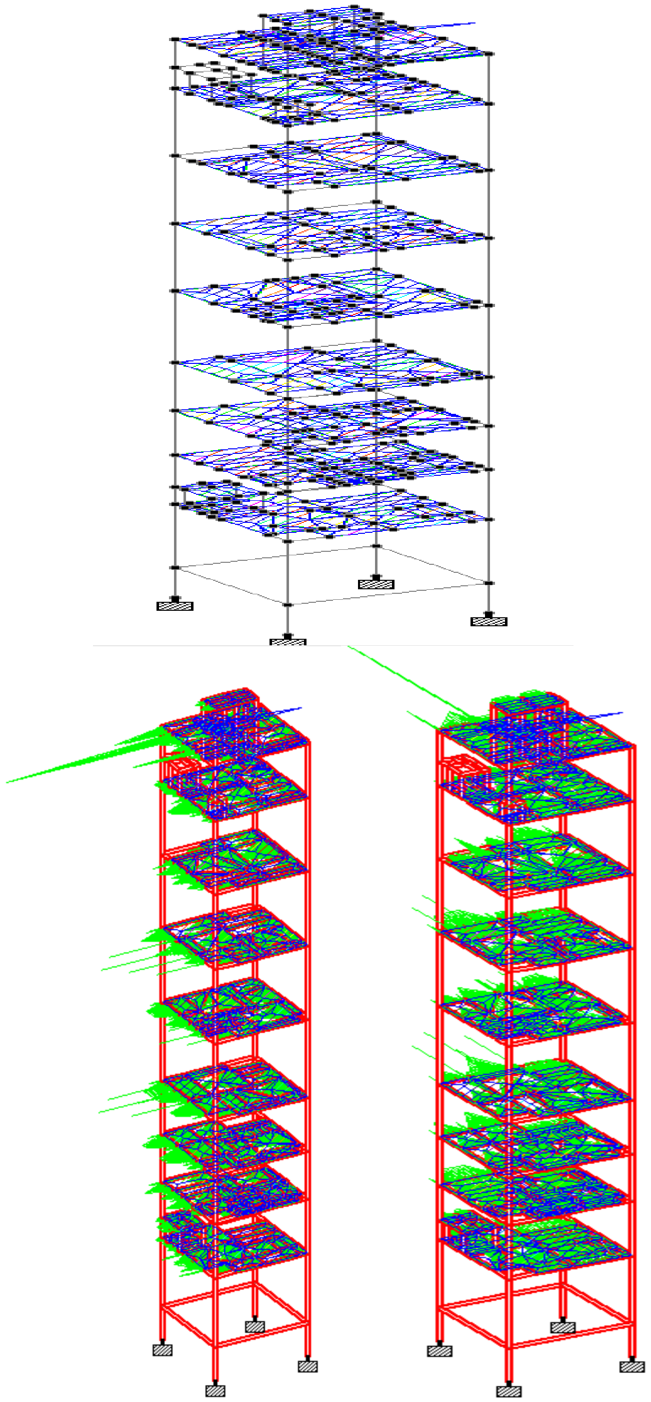


**Fig2:Assigning Of Dead Loads & Seismic Loads**

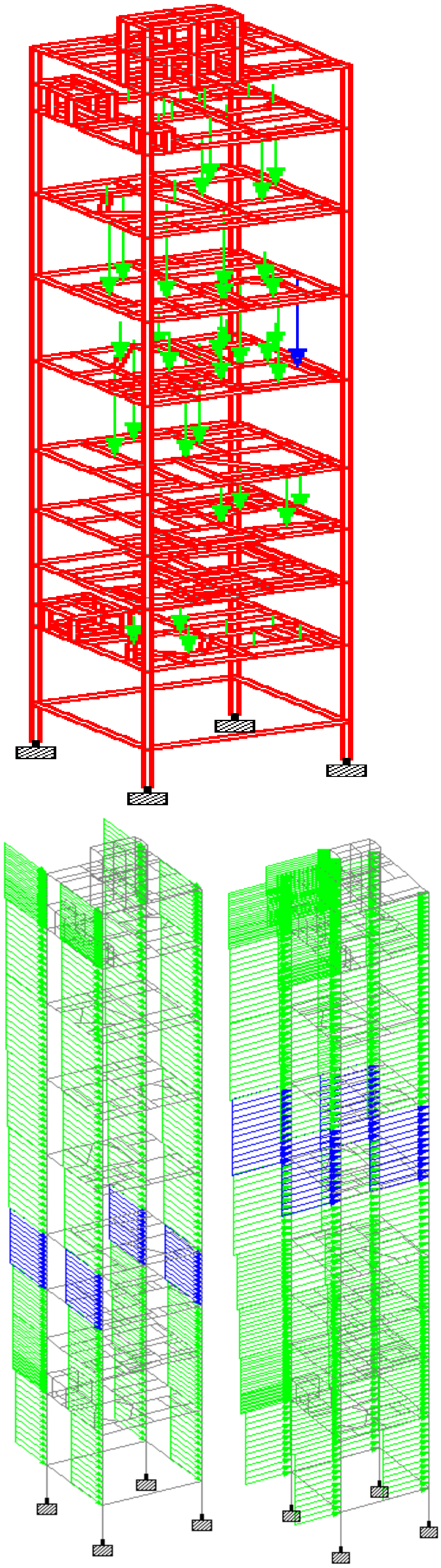


Fig3:Assigning Of Equipmental Loads & Wind Loads

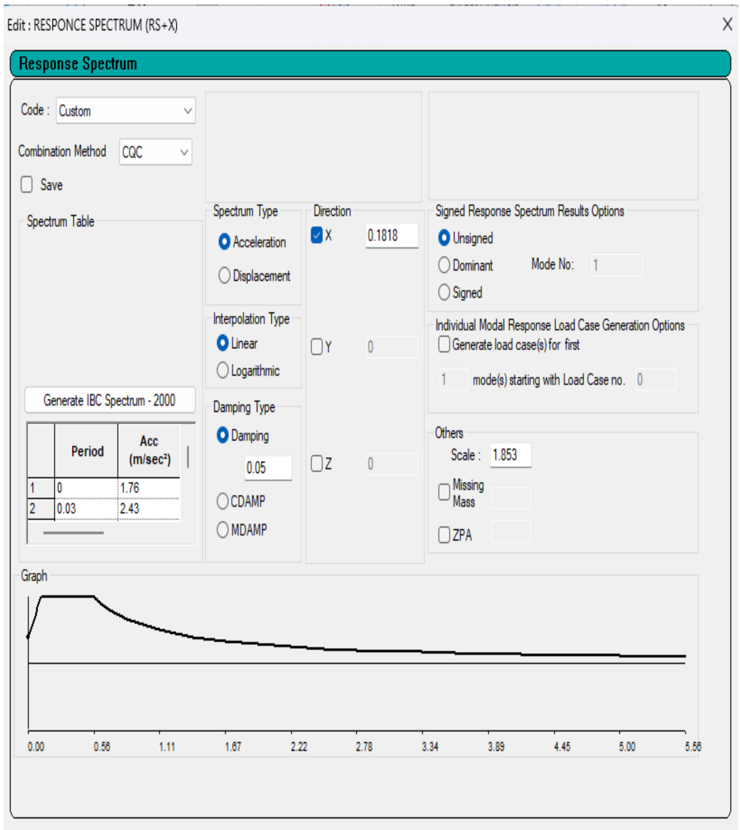



Fig4:Response spectrum along -X

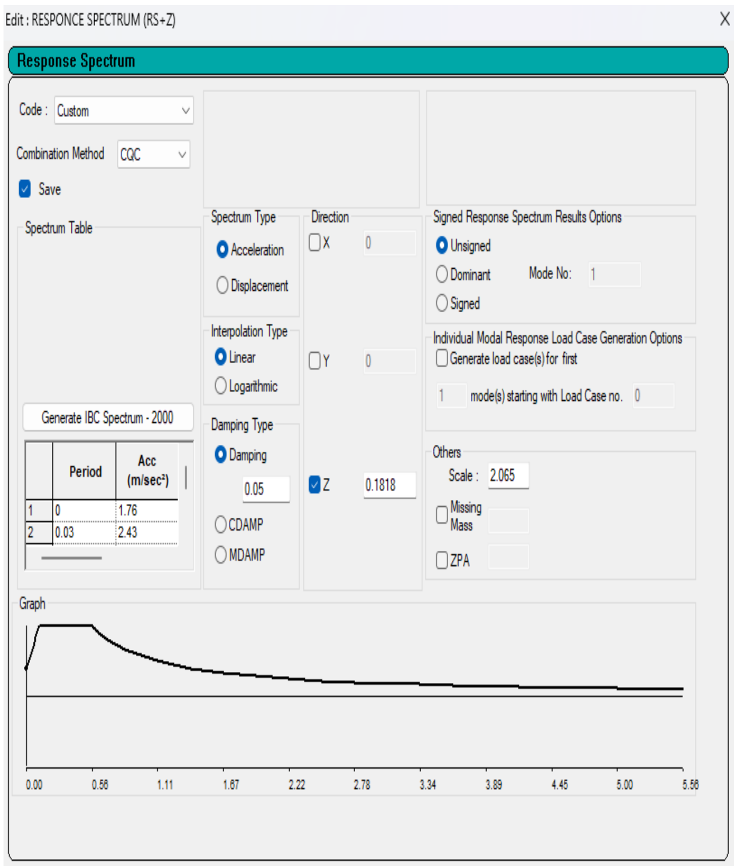
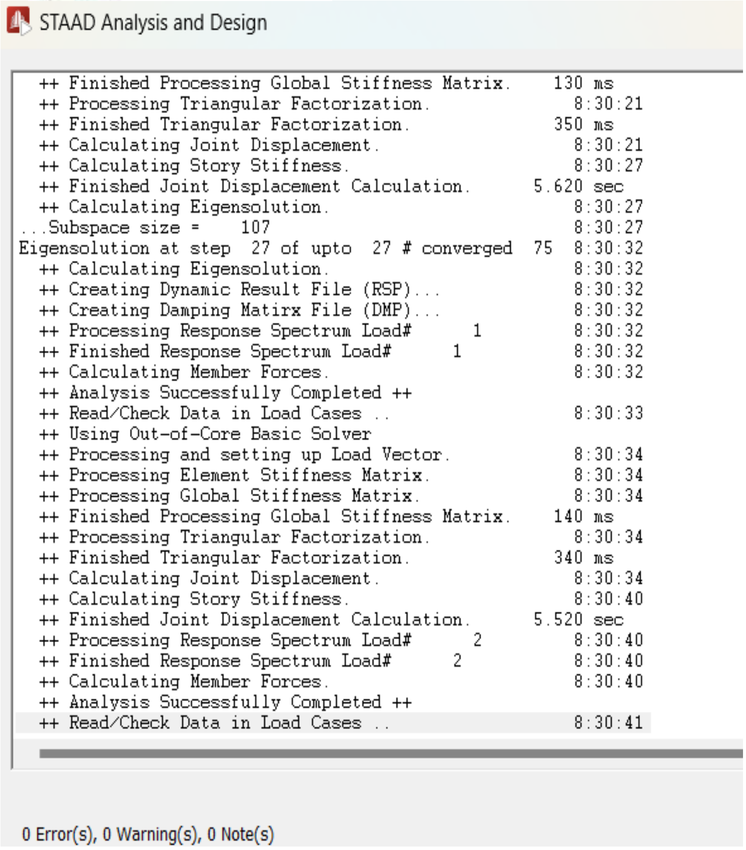



Fig4:Response spectrum along -Z

**LOAD COMBINATIONS**

LOAD COMB 10 ULC, 1.5 DEAD + 1.5 LIVE
LOAD COMB 11 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 WIND (1)
LOAD COMB 12 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 WIND (2)
LOAD COMB 13 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 WIND (3)
LOAD COMB 14 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 WIND (4)
LOAD COMB 15 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 WIND (1)
LOAD COMB 16 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 WIND (2)
LOAD COMB 17 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 WIND (3)
LOAD COMB 18 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 WIND (4)
LOAD COMB 19 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 SEISMIC (1)
LOAD COMB 20 ULC, 1.2 DEAD + 1.2 LIVE + 1.2 SEISMIC (2)
LOAD COMB 21 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 SEISMIC (1)
LOAD COMB 22 ULC, 1.2 DEAD + 1.2 LIVE + -1.2 SEISMIC (2)
LOAD COMB 23 ULC, 1.5 DEAD + 1.5 WIND (1)
LOAD COMB 24 ULC, 1.5 DEAD + 1.5 WIND (2)
LOAD COMB 25 ULC, 1.5 DEAD + 1.5 WIND (3)
LOAD COMB 26 ULC, 1.5 DEAD + 1.5 WIND (4)
LOAD COMB 27 ULC, 1.5 DEAD + -1.5 WIND (1)
LOAD COMB 28 ULC, 1.5 DEAD + -1.5 WIND (2)
LOAD COMB 29 ULC, 1.5 DEAD + -1.5 WIND (3)
LOAD COMB 30 ULC, 1.5 DEAD + -1.5 WIND (4)
LOAD COMB 31 ULC, 1.5 DEAD + 1.5 SEISMIC (1)
LOAD COMB 32 ULC, 1.5 DEAD + 1.5 SEISMIC (2)
LOAD COMB 33 ULC, 1.5 DEAD + -1.5 SEISMIC (1)
LOAD COMB 34 ULC, 1.5 DEAD + -1.5 SEISMIC (2)
LOAD COMB 35 ULC, 0.9 DEAD + 1.5 WIND (1)
LOAD COMB 36 ULC, 0.9 DEAD + 1.5 WIND (2)
LOAD COMB 37 ULC, 0.9 DEAD + 1.5 WIND (3)
LOAD COMB 38 ULC, 0.9 DEAD + 1.5 WIND (4)
LOAD COMB 39 ULC, 0.9 DEAD + -1.5 WIND (1)
LOAD COMB 40 ULC, 0.9 DEAD + -1.5 WIND (2)
LOAD COMB 41 ULC, 0.9 DEAD + -1.5 WIND (3)
LOAD COMB 42 ULC, 0.9 DEAD + -1.5 WIND (4)
LOAD COMB 43 ULC, 0.9 DEAD + 1.5 SEISMIC (1)
LOAD COMB 44 ULC, 0.9 DEAD + 1.5 SEISMIC (2)
LOAD COMB 45 ULC, 0.9 DEAD + -1.5 SEISMIC (1)
LOAD COMB 46 ULC, 0.9 DEAD + -1.5 SEISMIC (2)

## 5.SOFTWARES USED



STAAD Analysis and Design

```
 ++ Finished Processing Global Stiffness Matrix.    130 ms
 ++ Processing Triangular Factorization.              8:30:21
 ++ Finished Triangular Factorization.              350 ms
 ++ Calculating Joint Displacement.                   8:30:21
 ++ Calculating Story Stiffness.                      8:30:27
 ++ Finished Joint Displacement Calculation.       5.620 sec
 ++ Calculating Eigensolution.                        8:30:27
...Subspace size =     107                            8:30:27
Eigensolution at step  27 of upto  27 # converged  75  8:30:32
 ++ Calculating Eigensolution.                        8:30:32
 ++ Creating Dynamic Result File (RSP)...             8:30:32
 ++ Creating Damping Matirx File (DMP)...             8:30:32
 ++ Processing Response Spectrum Load#      1         8:30:32
 ++ Finished Response Spectrum Load#      1           8:30:32
 ++ Calculating Member Forces.                        8:30:32
 ++ Analysis Successfully Completed ++
 ++ Read/Check Data in Load Cases ..                  8:30:33
 ++ Using Out-of-Core Basic Solver
 ++ Processing and setting up Load Vector.            8:30:34
 ++ Processing Element Stiffness Matrix.              8:30:34
 ++ Processing Global Stiffness Matrix.               8:30:34
 ++ Finished Processing Global Stiffness Matrix.    140 ms
 ++ Processing Triangular Factorization.              8:30:34
 ++ Finished Triangular Factorization.              340 ms
 ++ Calculating Joint Displacement.                   8:30:34
 ++ Calculating Story Stiffness.                      8:30:40
 ++ Finished Joint Displacement Calculation.       5.520 sec
 ++ Processing Response Spectrum Load#      2         8:30:40
 ++ Finished Response Spectrum Load#      2           8:30:40
 ++ Calculating Member Forces.                        8:30:40
 ++ Analysis Successfully Completed ++
 ++ Read/Check Data in Load Cases ..                  8:30:41
```

0 Error(s), 0 Warning(s), 0 Note(s)

**Fig5:Analysis of the model**

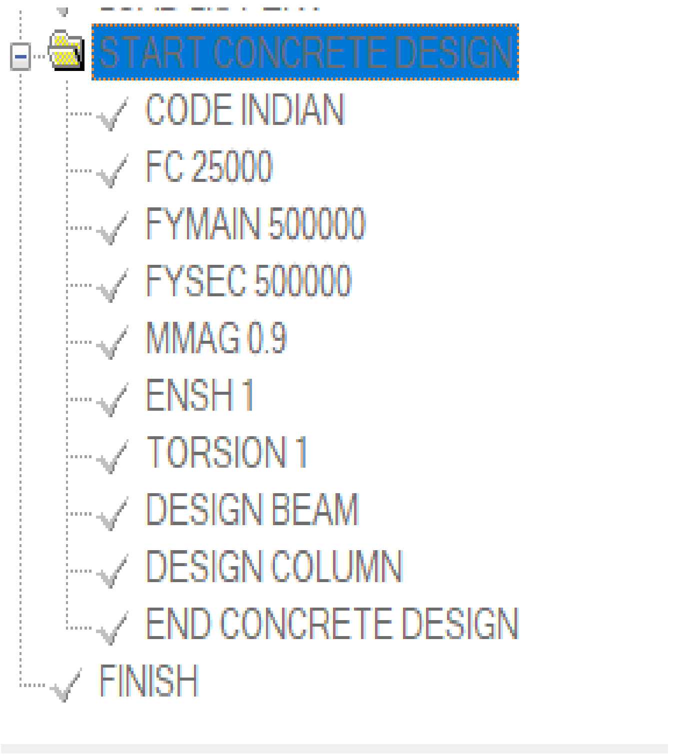



**Fig6: Concrete Design using the Staad mode**

```
         IS-456   L I M I T   S T A T E   D E S I G N
       C O L U M N   N O.     5 D E S I G N   R E S U L T S

    M30                   Fe500 (Main)             Fe500 (Sec.)

 LENGTH:  5000.0 mm   CROSS SECTION: 2000.0 mm X 2000.0 mm  COVER: 40.0 mm

 ** GUIDING LOAD CASE:    6 END JOINT:     5  TENSION COLUMN

 REQD. STEEL AREA   :    48000.00 Sq.mm.
 REQD. CONCRETE AREA:  3952000.00 Sq.mm.
 MAIN REINFORCEMENT : Provide  60 - 32 dia. (1.21%,  48254.86 Sq.mm.)
                      (Equally distributed)
 TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 300 mm c/c

 SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
 ----------------------------------------------------------
 Puz :  71352.00   Muz1 :  10759.12   Muy1 :  10759.12

 INTERACTION RATIO: 0.94 (as per Cl. 39.6, IS456:2000)

 SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
```

**Fig6: Column Design using the Staad mode**

```
             IS-456   L I M I T   S T A T E   D E S I G N
             B E A M  N O.   184  D E S I G N  R E S U L T S

      M30                  Fe500 (Main)               Fe500 (Sec.)

    LENGTH:  1300.0 mm      SIZE:   600.0 mm X 2250.0 mm   COVER: 30.0 mm

                      SUMMARY OF REINF. AREA (Sq.mm)
 -------------------------------------------------------------------------
 SECTION     0.0 mm      325.0 mm     650.0 mm     975.0 mm     1300.0 mm
 -------------------------------------------------------------------------
  TOP       4077.48      3649.72      3239.34      2839.91      2450.79
 REINF.    (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)

 BOTTOM     2247.87      2247.87      2247.87      2247.87      2280.85
 REINF.    (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)     (Sq. mm)
 -------------------------------------------------------------------------

                      SUMMARY OF PROVIDED REINF. AREA
 -------------------------------------------------------------------------
 SECTION     0.0 mm      325.0 mm     650.0 mm     975.0 mm     1300.0 mm
 -------------------------------------------------------------------------
  TOP      13-20d       12-20d       11-20d       10-20d        8-20d
 REINF.   2 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)   1 layer(s)

 BOTTOM    29-10d       29-10d       29-10d       29-10d       30-10d
 REINF.   2 layer(s)   2 layer(s)   2 layer(s)   2 layer(s)   2 layer(s)

 SHEAR   2 legged 12d 2 legged 12d 2 legged 12d 2 legged 12d 2 legged 12d
 REINF.  @ 155 mm c/c @ 155 mm c/c @ 155 mm c/c @ 155 mm c/c @ 105 mm c/c
 -------------------------------------------------------------------------

 Provide  6-12d  along each face of the beam (Side face reinf.)
```

**Fig6: Beam Design using the Staad mode**

## CONCLUSION

Analysis and designing were done by using software and successfully vindicated manually as per IS456-2000.

Computation by both manually as well as software analysis, gives nearly same result.

Analysis is based on the site conditions of having no seismic governing site but considered for Seismic analysis is based in IS 1893 Part 1.

Quantity of steel provided for building is economical and adequate.

Stadd has the capability to design structures based on site condition and also by combining the types of codes used for designing as per the user demands.

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