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Role of Importance Factor on Reinforcing Steel

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Abstract: Aim is to study the change in reinforcing steel (percentage change) once we change the Importance Factor during the seismic analysis of a building. Importance factor classifies various structures on the basis of value 1 or 1.5 or even more depending on the structure importance. This value is provided in the seismic analysis of a building using STAAD PRO V8i version. The current code gives the Importance Factor value as "1" in case of "general buildings" and "1.5" in case of public or we can say important buildings. It also makes important buildings as heavier sections by increasing design base shear. There is no proof that how this importance factor works or improves the seismic factors of a building. In this study, the aim is to make a simple Bay frame using STAAD PRO for the purpose of analysis under seismic conditions and varying this respective importance factor and noticing the percentage change in steel reinforcement and the type of bars that are being used.
Keywords: Seismic Analysis, STAAD PRO V8i, reinforcement, loads, importance factor.

I. INTRODUCTION

The interest that persuaded to move forward with this research is to understand the kind of behaviour that reinforcing steel shows once the Importance Factor will be changed or varied accordingly. Especially in the hilly areas of the Himalayan ranges including the area of Jammu and Kashmir where the seismic zone comes under the zone-5 category, which clearly means that it is prone to disasters at a very high probability as it has always been, dating back to the nearest one in 2005, in which a massive earthquake took place which led to the loss of almost 1,00,000 lives. The aim is to develop an interest in making disaster proof structures especially earthquake resistant buildings but at the same time understand the type of effects it will have on quantity as well as the qualitative aspect of a particular building. For that purpose, STAAD PRO V8i version was chosen on which a simple Bay frame structure is to be created and the respective loading will be calculated and Importance Factor will be varied.

II. BASIC OVERVIEW

The current Indian Seismic Design Code provides the way of determination of design base shear using particular equation which comprises of zone factor, importance factor and response reduction factor as well as spectral acceleration based on building fundamental time and total gravity weight. There are various kinds of studies which will provide us the proper value of zone factor, response reduction factor and spectral acceleration, but there are no proper evidences related to the importance factor, on what basis this value is assigned. This value is mainly taken as 1 and 1.5 for regular and important buildings such as hospitals, museums, disaster management building offices etc.

A. Building Design Details

As the structure is created in STAAD PRO V8i version, the run structure wizard option is used to create a simple bay frame with length equal to 12 meter, height equal to 15 metre and width equal to 12 meter. The number of bays along the length, breadth and height are kept as 4, 5, 4 respectively. The dimensions of the building were chosen in such a manner that it will fulfil the criteria of the type of beams and columns that are commonly used with beam dimensions being 400mm × 400mm and column dimensions being 450mm × 400mm.

B. Assigning The Basic Factors

Once the frame was created, the beams, columns and the plates were created and respective thickness and dimensions were assigned to them and after that the fixed load is assigned at the base using front elevation view option of the taskbar.

C. Assigning Seismic Parameters

Model IS 1893/2002/2005 code is used and then, generate option is used, the city is chosen as Srinagar which generated a Zone Factor $Z= 0.36$. The soil was kept as hard soil and damping factor was 5%. The importance factor is initially kept as "1". The period in X and the period in Z was calculated respectively with the help of formula given as:

$$\frac{0.9H}{\sqrt{(Dxz)}}$$

Where, H= Height of the building
Dx= Distance in X-direction
Dy= Distance in Y-direction

$$= \frac{.9 \times 15}{\sqrt{12}} = 0.38$$

Self weight escaped equal to 1
Member beat option is selected with UNI option and meanwhile load is kept as 14 Kn/m2
Include weight option, pressure is kept as -3.75 Kn/m2

III.LOAD CASE DETAILS

All in lower case details, firstly, seismic parameters are entered as:

1) EQ+X (value kept as 1 in X direction)
2) EQ-X (value kept as -1 in X direction)
3) EQ+Z (value kept as 1 in Z direction)
4) EQ-Z (value kept as -1 in Z direction)
5) DEAD LOAD
   SELF WEIGHT = -1 (in Y-direction)
   Floor Load = -3.75 Kn/m2

6) Floor Load = -2

After performing the analysis, the option of concrete design is used which consists of code IS-13920 with other parameters being:

Fc = 30
Fy Main = 500
Fy Sec= 500
Max Main = 25mm
Max Sec = 12mm
Min Main = 20mm
Min Sec = 8mm

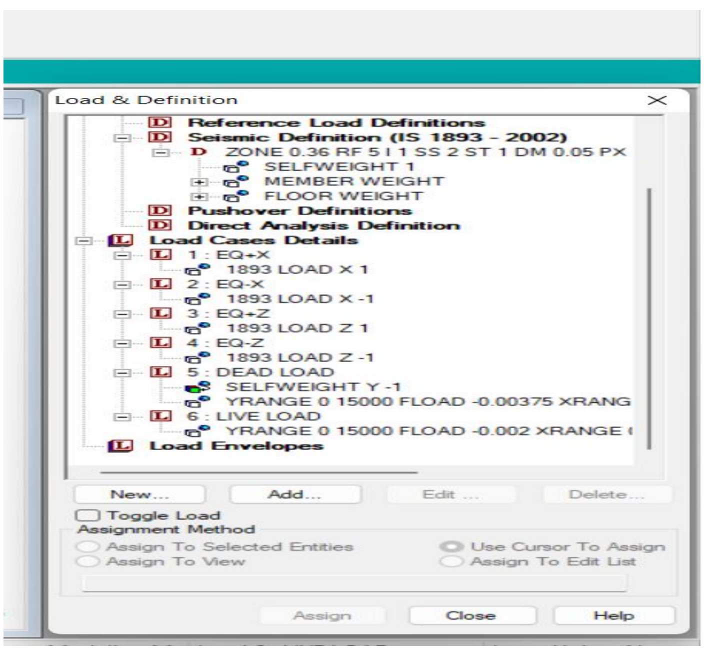

Fig. 1: Shows Load Case Details for Seismic Analysis

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IV. ANALYSIS

Once all the values are inserted, the run analysis option is used in order to check for errors after receiving zero errors, the reading is noted for observing the change in the reinforcing steel amount with respect to the change in importance factor, column #30 is taken as a reference column in order to observe the change in the required area of steel and the required area of concrete and the number of bars that are going to be used. All this data is represented in table number one in tabular form below :

TABLE I Area of reinforcing steel, percentage change in a reinforcement with respect to the importance factor, main rebars.

Importance Factor	Variation in reinforcement		
	Area of Steel Required	Percentage Increase in Area of Steel	Main Reinforcement
1	1440mm2	-	8-20mm diameter (equally distributed)
1.5	2304mm2	37.5%	8-20mm diameter (equally distributed)
2	3204mm2	23.80%	12-20mm diameter (equally distributed)
2.5	3888mm2	22.22%	8-25mm diameter (equally distributed)

V. RESULTS

By the research that was carried out, it was analysed that the column #30 is showing variation in the amount of steel that is going to be used as reinforcement by changing the importance factor from 1, 1.5, 2, 2.5 which is affecting and increasing the amount of steel that is going to be used in a particular column by 31.5% an important factor is increased from 1 to 1.5, 23.80% when importance factor is increased from 1.5 to 2 and 22.22% when importance factor is increased from 2 to 2.5. Thereby, utilizing a lot of steel but ultimately providing necessary safety which is required as per IS-code specifications. Moreover, if pushover analysis is performed for this particular Bay frame, and a graph is plotted with pushover analysis based share and top displacement, importance factor recognized as 1 will have less base shear and importance factor recognized with 1.5,2, 2.5 has higher base shear as this is obvious with the increase in importance factor, the section becomes heavier which results in higher base shear when compared to that of importance factor of 1. The percentage increase in base share with variation of importance factor as 1.25, 1.5, 1.75 are 14%, 44%, 72% respectively.


```
        C O L U M N   N O.    30  D E S I G N   R E S U L T S

      M30                  Fe500 (Main)              Fe500 (Sec.)

  LENGTH:  3000.0 mm   CROSS SECTION:  400.0 mm X  450.0 mm  COVER: 40.0 mm

  ** GUIDING LOAD CASE:    2 END JOINT:    10  TENSION COLUMN

  REQD. STEEL AREA   :     1440.00 Sq.mm.
  REQD. CONCRETE AREA:   178560.00 Sq.mm.
  MAIN REINFORCEMENT : Provide   8 - 20 dia. (1.40%,   2513.27 Sq.mm.)
                      (Equally distributed)
  CONFINING REINFORCEMENT  : Provide 12 mm dia. rectangular ties @ 100 mm c/c
                             over a length   500.0 mm from each joint face towards
                             midspan as per Cl. 7.4.6 of IS-13920.
                              2 number overlapping hoop along with crossties
                             are provided along Y direction.
                             (Clause 7.3.2 of IS-13920)
                              2 number overlapping hoop along with crossties
                             are provided along Z direction.
                             (Clause 7.3.2 of IS-13920)
  TIE REINFORCEMENT        : Provide  8 mm dia. rectangular ties @ 200 mm c/c
```

Fig. 2: STAAD FILE information about column 30 when importance factor “I”=1

```
STAAD SPACE                                                -- PAGE NO.  436

===========================================================================

        C O L U M N   N O.    30  D E S I G N   R E S U L T S

     M30                    Fe500 (Main)               Fe500 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  400.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    3 END JOINT:     10  TENSION COLUMN


REQD. STEEL AREA    :       2304.00 Sq.mm.
REQD. CONCRETE AREA:    177696.00 Sq.mm.
MAIN REINFORCEMENT : Provide   8 - 20 dia. (1.40%,    2513.27 Sq.mm.)
                     (Equally distributed)
CONFINING REINFORCEMENT  : Provide 12 mm dia. rectangular ties @ 100 mm c/c
                           over a length   500.0 mm from each joint face towards
                           midspan as per Cl. 7.4.6 of IS-13920.
                            2 number overlapping hoop along with crossties
                           are provided along Y direction.
                           (Clause 7.3.2 of IS-13920)
                            2 number overlapping hoop along with crossties
                           are provided along Z direction.
                           (Clause 7.3.2 of IS-13920)
TIE REINFORCEMENT        : Provide  8 mm dia. rectangular ties @ 200 mm c/c
```

Fig. 3 A STAAD FILE information about column 30 when importance factor “I” = 1.5

```
        C O L U M N   N O.    30  D E S I G N   R E S U L T S

     M30                    Fe500 (Main)               Fe500 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  400.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    3 END JOINT:     10  TENSION COLUMN


REQD. STEEL AREA    :       3024.00 Sq.mm.
REQD. CONCRETE AREA:    176976.00 Sq.mm.
MAIN REINFORCEMENT : Provide  12 - 20 dia. (2.09%,    3769.91 Sq.mm.)
                     (Equally distributed)
CONFINING REINFORCEMENT  : Provide 10 mm dia. rectangular ties @ 100 mm c/c
                           over a length   500.0 mm from each joint face towards
                           midspan as per Cl. 7.4.6 of IS-13920.
                            3 number overlapping hoop along with crossties
                           are provided along Y direction.
                           (Clause 7.3.2 of IS-13920)
                            3 number overlapping hoop along with crossties
                           are provided along Z direction.
                           (Clause 7.3.2 of IS-13920)
TIE REINFORCEMENT        : Provide  8 mm dia. rectangular ties @ 200 mm c/c
```

Fig. 4 A STAAD FILE information about column 30 when Importance Factor “ I” = 2

```
        C O L U M N   N O.    30  D E S I G N   R E S U L T S

     M30                    Fe500 (Main)               Fe500 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  400.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    3 END JOINT:     10  TENSION COLUMN

--------------------------------< PAGE 429 Ends Here >---------------------------
 STAAD SPACE                                               -- PAGE NO.  430


REQD. STEEL AREA    :       3888.00 Sq.mm.
REQD. CONCRETE AREA:    176112.00 Sq.mm.
MAIN REINFORCEMENT : Provide   8 - 25 dia. (2.18%,    3926.99 Sq.mm.)
                     (Equally distributed)
CONFINING REINFORCEMENT  : Provide 12 mm dia. rectangular ties @ 100 mm c/c
                           over a length   500.0 mm from each joint face towards
                           midspan as per Cl. 7.4.6 of IS-13920.
                            2 number overlapping hoop along with crossties
                           are provided along Y direction.
                           (Clause 7.3.2 of IS-13920)
                            2 number overlapping hoop along with crossties
                           are provided along Z direction.
                           (Clause 7.3.2 of IS-13920)
TIE REINFORCEMENT        : Provide  8 mm dia. rectangular ties @ 200 mm c/c
```

Fig. 5 A STAAD FILE information about column 30 when Importance Factor “I”=2.5

VI. CONCLUSION

The current IS-code defines the Importance Factor for buildings as “1” for “general buildings” and “1.5” for “public buildings”. Present study focused on how buildings will behave under different importance factors that will be used for design and its effects on reinforcement that as the important factor increases, the area of reinforcing steel also goes on increasing and the design based share value increases which makes the structure as heavy, however, there are no considerable changes in strength factor and allowable stress factor.

VII. ACKNOWLEDGEMENT

I would like to thank my project mentor and guide Mr. Gaurav Tomar for guiding me throughout the process of my findings and at the same time helping me interlink my major project which is “Analysis and Design of a Community Building using STAAD PRO V8i software” with the process of finding percentage change in the reinforcing steel with respect to the importance factor variation. He has been really helpful throughout the process and has encouraged my morale to go on with my findings with respect to my field of interest about creation of earthquake resistant structural awareness among the people living in disaster prone zones.

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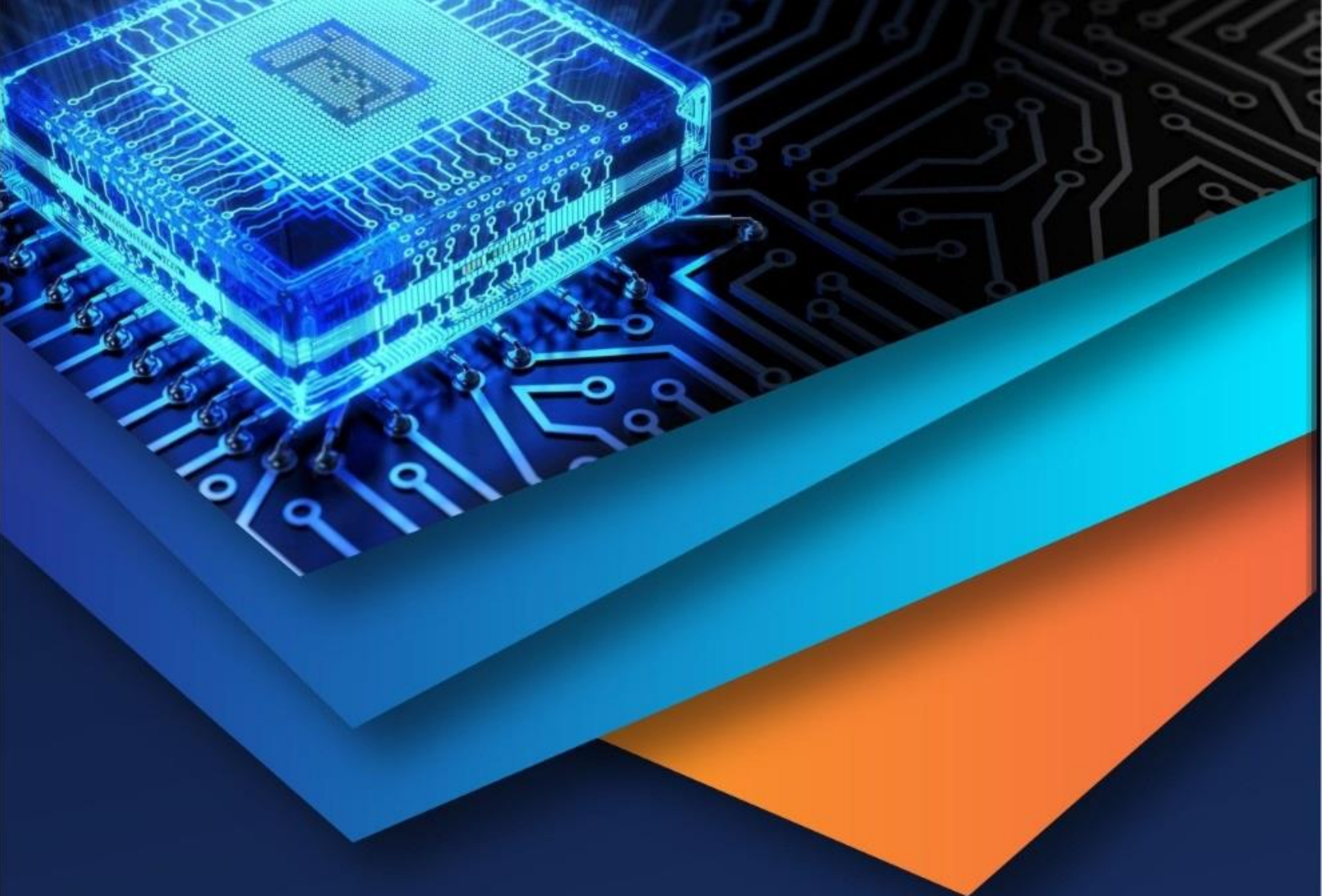

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