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COMPARISON OF Fe415 AND Fe500 STEEL IN TWO-STOREY RCC BUILDING USING STAAD PRO

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ABSTRACT

Plain concrete is made by mixing cement, fine aggregate (sand), coarse aggregate (gravel), and water .When reinforcing steel is placed in concrete, the solidified mass is called reinforced concrete. Strength, durability, surface texture and economy of concrete are all influenced by the choice of materials, by the manner they are proportioned in the concrete and by the precision with which the concrete can be produced. Rebar (short for reinforcing bar), collectively known as reinforcing steel and reinforcement steel, is a steel bar or mesh of steel wires used as a tension device in reinforced concrete and reinforced masonry structures to strengthen and hold the concrete in tension. Rebar's surface is often patterned to form a better bond with the concrete. Rebars are available in the following grades as per IS: 1786-2008 Fe415, Fe415D ,Fe415S,Fe500,Fe500D,Fe 500S,Fe 550, Fe550D, Fe600.In this research work I am studying change in area of steel of beams and column under same loading conditions of same size in same seismic zone but with different grades of steel of Fe415 & Fe500 and optimized cost of steel reinforcement in a project but also regarding ductility characteristics of Fe415 & Fe500 using STAAD Pro. The result of my paper that we would be using Fe500 instead of Fe415 due to its many advantage over the latter.

Keywords- rebars, seismic zone, optimized cost, ductility.

I.INTRODUCTION

Plain concrete is made by mixing cement, fine aggregate (sand), coarse aggregate (gravel), and water. When reinforcing steel is placed around concrete, the solidified mass is called reinforced concrete. Strength, durability, surface texture and economy of concrete are all influenced by the choice of materials, by the manner they are proportioned in the concrete and by the precision with which the concrete can be produced.

Probable variations in loads and reinforcement steels grades and strengths largely affects the life and sustainability of the Structure specifically in high seismic Zones i.e. Zone IV & V. Main objective of this work is to reduce the tendency of structural failure during the execution phase ultimately reducing the risk of injury, and reducing weight, durability and cost of the Structure in construction projects. Through this work, it is intended to optimize the cost of the various structural elements and ultimately the overall project cost and to achieve maximum economy in the design which in turn leads to durability and sustainability of the Building. Comparison of structural Design of Two Storey R.C.C. Structure using Steel Bars of Grade Fe415& Fe500, to

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evaluate the strength, cost factor and structural performance characteristics of Reinforcement steel of Grades Fe415 and Fe500 and comparing in terms of tensile strength and durability of the R.C.C. Structures with optimization of the overall cost of projects of construction industry.ISO issues certifications if the bar meets a certain requirement. Fe415 means than the yield strength of the bar is 415 N/mm2. With just a little change in the treatment process, we can get different grades of steel with different properties.

The most common confusion arises in choosing between Fe 415 and Fe 500 grade reinforcing bars. Hence we have to compare the Grades Fe415 and Fe500 to select the best one as per our requirements.

The rationale of our study is to compare and analyze the Fe415 and Fe500 grades of Reinforcing Steel used in concrete in various types R.C.C structures for Buildings. The reinforcement should be according to the following requirement:-

1. It must fulfill the Strength requirements and durability
2. It should be economical.
3. It should be well resistant to weathering agencies like rusting etc.

The purpose of our project is fulfillment of the above described requirement. Analysis will be carried out on STAAD for Fe415 & Fe500 and one main Beam and one column (from both output files) will be selected for comparison of the reinforcement steel. STAAD-PRO software is used to design the beams and columns by taking into consideration the different loading conditions in various members. Design parameters of both Fe415 and Fe500 Grade will be compared to select best suitable grade of steel in seismic zone IV.

1.2. Ductility

Ductility is an ability of any material / structural element to deform, without collapse, even after reaching the failure load. This property protects the rupture / structural collapse or prolongs the rupture / collapse process. Materials with no ductility are brittle ones. Structures with no ductility can't resist the failure load without sudden collapse.

II.LITERATURE REVIEW

Amit Aneja, Simranjit Singh,Prof. Hemant Sood, Sonia, Jasvir S. Rattan (2001) - This paper surveys the change in physical properties (tensile strength, yield strength, elongation)of different steel grades (Fe 500 and Fe 500D)of different steel make (Tata Tiscon and SAIL) which are commonly used in India with variable concrete cover i.e. 20, 25 and 30mm. These rebars were embedded in beams with concrete grade M35.The standard size of beam is 10 cm x10 cm x 50 cm. These rebars were tested after 120 days of curing in:-Normal water, Sulphate solution and Chloride solution. The properties so obtained were compared with those of virgin rebars, so that we can find out the decrement in the physical properties of steel after extraction of rebars from beams with concrete grade M35. Nature of the steel and the positive and negative effects of the unmistakable strong spreads in RCC are found to survey the best level of steel required for improvement and to pick the best brand of rebars among differing assessment of steel with particular strong spread. Hence this provides the basis of our experimentation.

L.Gardner[a], N.R.Baddoo[b] (2006) - Despite significant progress in recent years in the development of room temperature design guidance for stainless steel structures, fire resistant design has received relatively little attention. This paper reports on studies carried out to investigate the performance of unprotected stainless steel beams and columns in fire. Material tests were carried out on five grades of stainless steel to determine strength and stiffness retention factors at elevated temperatures; both strength and stiffness retention were shown to be superior to that of carbon steel beyond 600 °C. Design recommendations for stainless steel columns and stainless steel beams supporting a concrete slab, based on the ECCS model code for fire engineering, were validated against the test and finite element results.

JuChen BenYoung (2007) - This paper presents the mechanical properties data for cold-formed steel at elevated temperatures. The deterioration of the mechanical properties of yield strength (0.2% proof stress) and elastic modulus are the primary properties in the design and analysis of cold-formed steel structures under fire. However, values of these properties at different temperatures are not well reported. Therefore, both steady and transient tensile coupon tests were conducted at different temperatures ranged approximately from 20 to 1000 °C for obtaining the mechanical properties of cold-formed steel structural material. This study included cold-formed steel grades G550 and G450 with plate thickness of 1.0 and 1.9 mm, respectively. Curves of elastic modulus, yield strength obtained at different strain levels, ultimate strength, ultimate strain and thermal elongation versus different temperatures are plotted and compared with the results obtained from the Australian, British, European standards and the test results predicted by other researchers. A unified equation for yield strength, elastic modulus, ultimate strength and ultimate strain of cold-formed steel at elevated temperatures is proposed in this paper. A full strain range expression up to the ultimate tensile strain f or the stress–strain curves of cold-formed carbon steel at elevated temperatures is also proposed in this paper. It is shown that the proposed equation accurately predicted the test results.

N.R.Baddoo (2008) -Stainless steel has unique properties which can be taken advantage of in a wide variety of applications in the construction industry. This paper reviews how research activities over the last 20 years have impacted the use of stainless steel in construction. Significant technological advances in materials processing have led to the development of duplex stainless steels with excellent mechanical properties; important progress has also been made in the improvement of surface finishes for architectural applications Structural research programmers across the world have laid the ground for the development of national and international specifications, codes and standards spanning both the design, fabrication and erection processes. Recommendations are made on research activities aimed at overcoming obstacles to the wider use of stainless steel in construction. New opportunities for stainless steel arising from the shift towards sustainable development are reviewed, including its use in nuclear containment structures, thin-walled cladding and composite floor systems.

K Priyesh (2013) - India is among the fastest developing nation in the world with major constructions like bridges, dams, airports, residential buildings etc. In a developing economy where infrastructure is getting boom, strength of structural members is of great importance. This is where Thermo Mechanically Treated (TMT) bars scores over Cold twisted bars (or CTD bars). For understanding the proper behavior of structural members, physical properties, chemical composition, mean projected rib area and macrostructure are very essential.

Nowadays there are many companies which supply untreated and twisted deformed bars as TMT bars which would do much harm for structural stability. There is an urgent need to use the phrase Quenching and Tempering to label the TMT bars. This project is an effort to showcase the ways to identify good quality TMT bars.

Minakshi Vaghani, Dr. S.A. Vasanwala, Dr. A.K. Desai (2014) - Stainless steels have not traditionally been widely used as structural materials in building and civil engineering. Where the steels have been used for this purpose there has been some other imperative driving the design, usually corrosion resistance or architectural requirements rather than the inherent structural properties of the steel. The primary reason for this low use in structural applications is usually the perceived and actual cost of stainless steel as a material. Developments over the last 10 years, both in available materials and attitudes to durability, are now offering a new opportunity for stainless steels to be considered as primary structural materials. This paper introduces stainless steel alloys and briefly discusses the important properties and commercial aspects of these alloys relevant to structural designers. The paper also considers recent developments, particularly with respect to available alloys and considers obstacles to the wider use of stainless steels in structural engineering that are related to both supply chain costs and efficiency of design.

1Vinod Joshi, 2 Sohit Singh, 3 Shahzaad Ali, 4 Saurabh Bohra, 5 Saurabh Kumar (2014)

This paper discusses the effect of heat treatment process on micro grain structure of steel in different electrical furnaces at different temperature levels and varying the holding time and heat treatment mediums. This study shows the effect of heat treatment process (annealing, normalizing, hardening, and tempering) on micro grain structure of steel. By heat treating the steel the material properties like ductility, toughness, hardness, tensile strength can easily be changed which would suit our design. This study summaries the alteration of mechanical property of steel undergoing various heat treatment process in comparison to untreated samples.

Devnath khunte, Gopal Sahu, Prakash Kumar Sen, Ritesh Sharma, Shailendra Bohidar (2015)

In this paper, Author studies about the mechanical properties like Tensile strength, yield stress and elongation for different steels such as low carbon steel and stainless steel an various heat treatment like d find out the effect of annealing, quenching and normalizing on material properties through testing on using Universal Testing Machine UTM. Effect of various types of heat treatment on fracture toughness and hardness is also analyzed. Optimum heat treatment strategy for commercial steel appears to be tempering in the 900ºC temperature range, to get the best combination of high toughness and high hardness. After that heat treated samples are used for testing of different material properties. Result shows which heat treatment will be better for improving material properties of mild steel and stainless steel.

Er. N.K. Roy1, Er. R.R. Sandhwar2 (2015)

Concrete is very strong in compression but comparatively weak in tension. Steel is very strong in tension and provides tensile strength to concrete. The thermal expansion for both steel and concrete are approximately the same. This along with excellent bending ability property makes steel the best material for reinforcement in concrete structures. Since the invention of R.C.C in 1867, Mild steel was being used as reinforcing material. Plain mild steel (M.S) rebar of grade Fe-250 were used till 1960. Later on the high strength cold twisted deformed (CTD) bars were produced by cold working process. The yield stress of CTD bars are 415 MPa against 250 MPa of M.S rebars. Though the chemical compositions of M.S & CTD bars are same but the physical strength of CTD bars are 60% higher than the M.S steel bars. TMT (Thermo mechanically treated) bars were introduced in India during 1980-1985. TMT bars are having an optimum combination of high strength, ductility, bending ability and other desirable properties. Now days most of steel companies in India like SAIL, TISCO and RINL are producing Fe500 or Fe550garde of TMT bars and not Fe415 grade of steel bars. If a bridge requires consumption of 1000 tons of M.S. reinforcement for its construction and it is constructed with TMT bars in place of M.S bars, the net consumption will be only 400 tons.

Akshay Gaikwad1 A.A. Qureshi2 (2016)

There is growing interest within the reinforced concrete industry in using higher strength reinforcing steel for certain applications. This interest is driven primarily by relief of congestion; particularly in buildings assigned a high seismic design category. There are also other areas where high strength bar can help improve construction efficiencies, or - combined with high strength concrete - allow reinforced concrete to be used in more demanding applications. Most steel used for reinforcement is highly ductile in nature. Its usable strength is its yield strength, as this stress condition initiates such a magnitude of deformation (into the plastic yielding range of the steel), that major cracking will occur in the concrete. Several different grades of steel may be used for large projects, with a minimum grade for ordinary tasks and higher grades for more demanding ones. Cost increases generally for higher grades, so some feasibility studies must be made to see if the better steel in smaller quantities is really cheaper than a larger quantity of a lower grade. Actually, higher grades are often used to permit smaller concrete members, relating to the space problems for placement of the reinforcement. This study focuses on designing four models in STAAD Pro, each equipped with Fe415& Fe500 separately and presents a comparative study among the effects of grade of steel on the overall structural efficiency.

III.GAP AREA

The above study has been conducted regarding:

- Change in physical properties of different grades of steel (Fe500 and Fe 550) and of different steel make (TATA Tiscon and SAIL).
- Investigate the performance of unprotected stainless steel beams and column in fire conditions.
- Mechanical properties for cold formed steel at elevated temperature and deterioration of properties under fire of cold formed steel grades G550 and G450.
- Effect of heat treatment process on micro grain structure of steel in different elastic furnace at different temperature level and varying holding time and heat treatment mediums.
- Study of mechanical properties for different steels such as low carbon and stainless steel using UTM.
- Comparison between TMT and cold formed steel.

This research work is about comparison of Fe415 and Fe500 steel in R.C.C. two-storey building using STAAD Pro. In this study, comparison of their strength and ductility and analyzing the cost optimization is carried out. This study is analyzed using STAAD Pro as this research has never been done in STAAD Pro.

IV.OBJECTIVE

The objective is:

- Get access to dimensions of the existing building.
- To prepare the geometry of the structure in STAAD Pro.
- To validate it with codes.
- To study change in area of steel of beams and column under same loading conditions of same size in same seismic zone but with different grades of steel of Fe415 & Fe500.
- Optimized cost of steel reinforcement in a project but also regarding ductility characteristics of Fe415 & Fe500.
- Strength requirement fulfillment of the project.

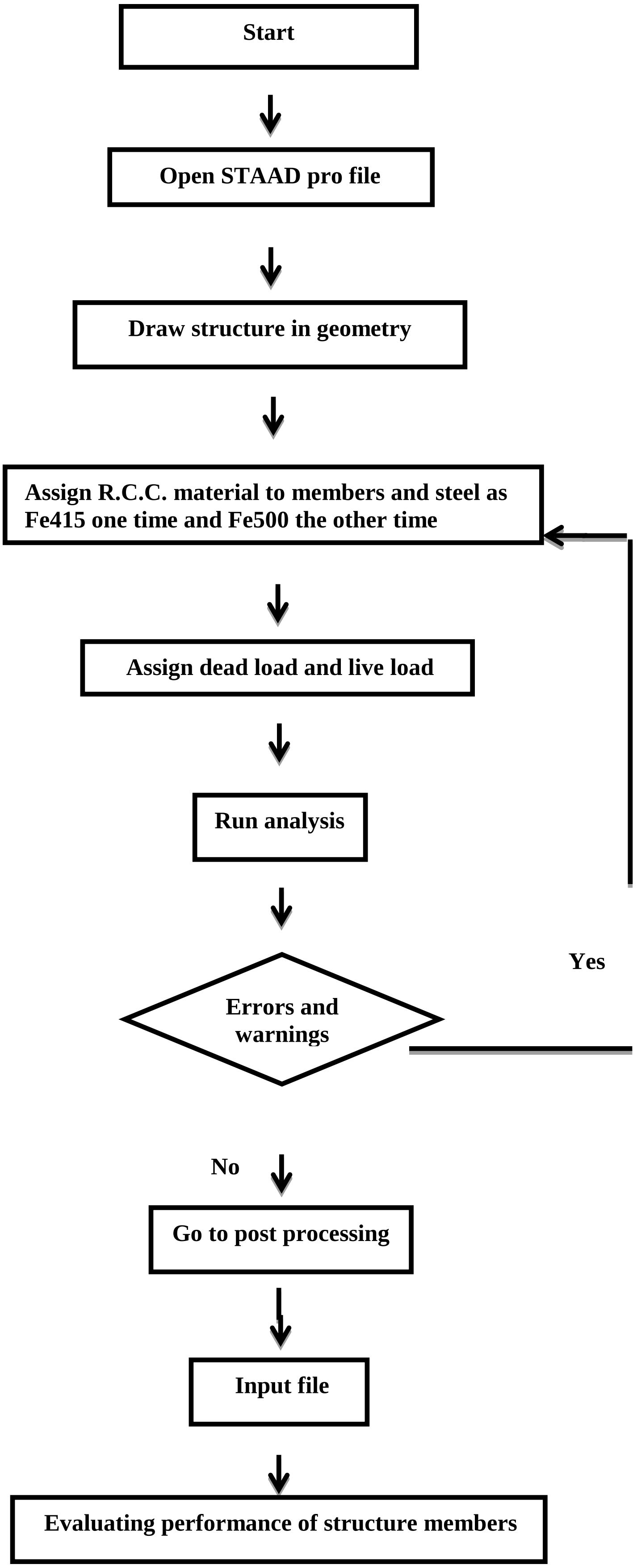
V.METHODOLOGY

The Reinforcement bars are used in the R.C.C structure for strengthening and reinforcing the Beams, slabs, columns and footing etc. The reinforcement increases the tensile strength of the concrete in addition to compressive strength. There are several types and grades of steel bars available in the market to reinforce concrete but according to strength and cost characteristics and availability of same in market, Steel Grades Fe415 and Fe500 are taken for analysis and design using STAAD Pro. Percentage of steel & Area of Reinforcement in Sq.mm. noted from output file of STAAD and compared for both grades of steel. Above methodology has been adopted so as to study the following:-

1. Observing the behaviour of structure due to the variation in the grades of reinforcing steel bars in the various elements of the two storeys R.C.C. framed structures.
2. Evaluating actual performance of the structural members subjected to different loading conditions in STAAD Pro.
3. Study the ductility of Fe415 and Fe500.
4. Comparing the results in terms of tensile strength, area of Reinforcement of Fe415 and Fe500 Grades by working out the loads or forces, moments and deflections or deformations etc. in the R.C.C frame.
5. Analysing the cost difference between Fe415 and Fe500.

VI. FLOWCHART OF METHODOLOGY

A flowchart has been created for the respective methodology below. This flowchart represents the stepwise method that has been carried out in the making of this project.

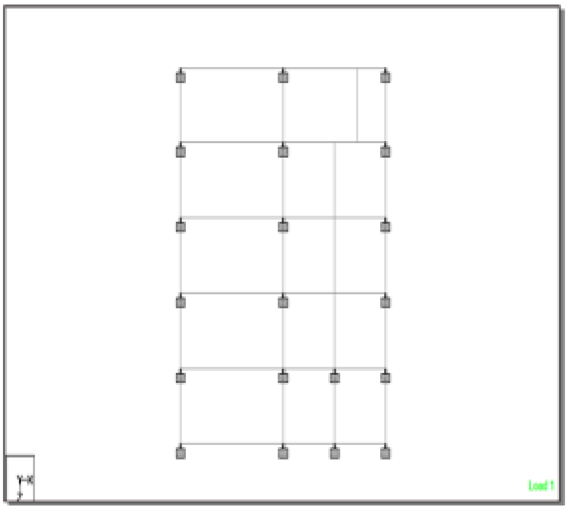

Start
Open STAAD pro file
Draw structure in geometry
Assign R.C.C. material to members and steel as Fe415 one time and Fe500 the other time
Assign dead load and live load
Run analysis
Errors and warnings
Yes
No
Go to post processing
Input file
Evaluating performance of structure members

Comparing results of Fe415 and Fe500 grades of steel

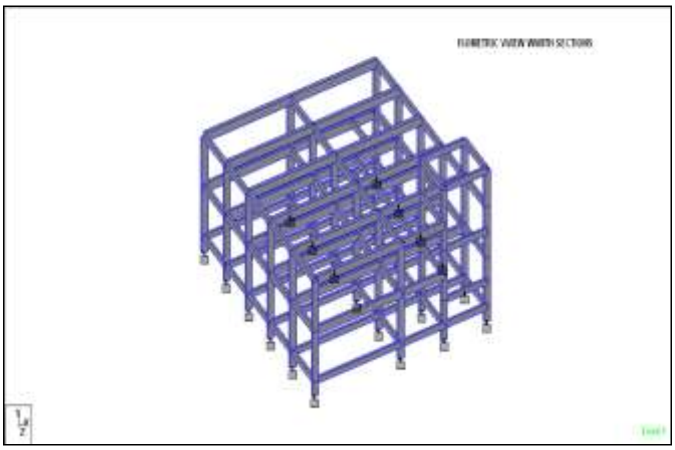
Stop

VII.STAAD PRO DRAWINGS

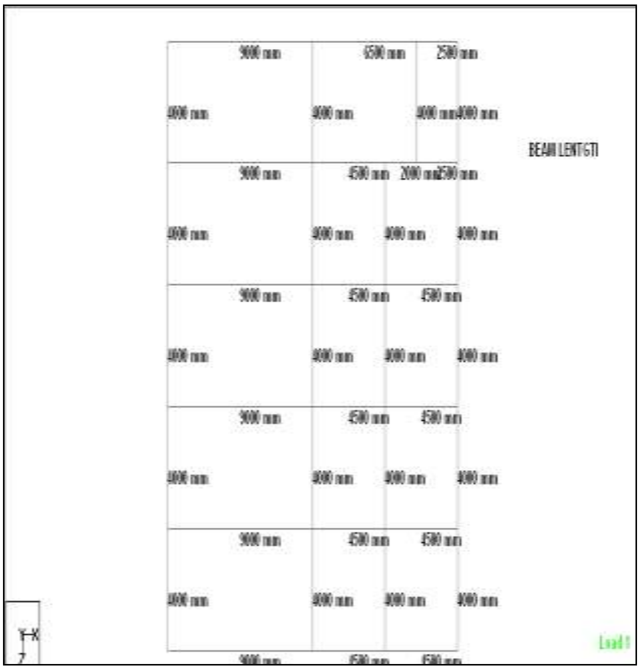
PLAN SHOWING POSITION OF COLUMNS AND SUPPORT



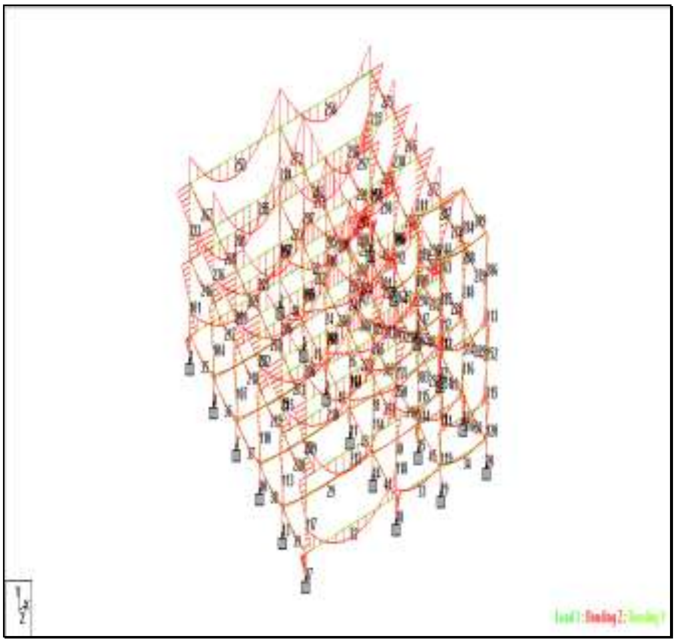
ISOMETRIC VIEW OF THE R.C.C. TWO STOREYED FRAMED STRCUTURE



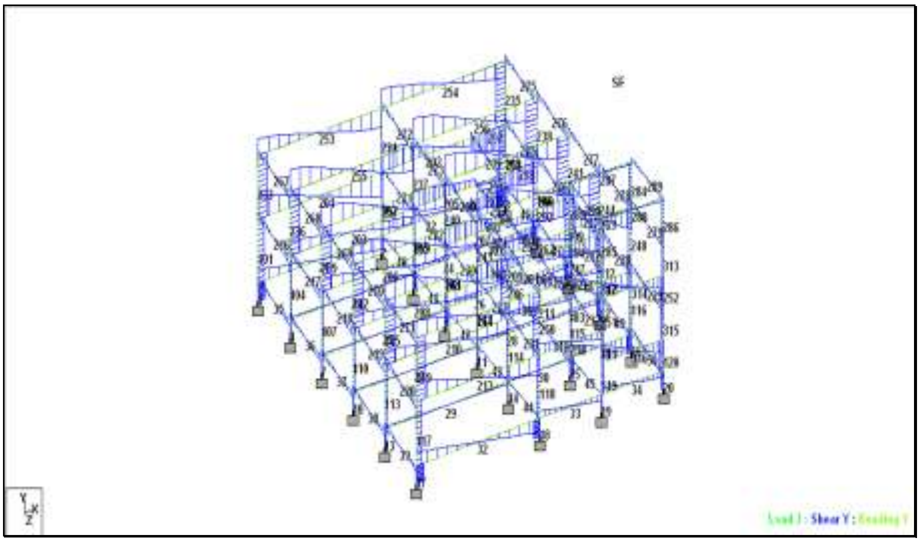
BEAM LENGTHS FOR STRUCTURAL MEMBERS IN R.C.C. FRAME



BENDING MOMENT DIAGRAMS FOR R.C.C. STRUCTURE AT ALL LEVELS



SHEAR FORCE DIAGRAMS FOR R.C.C. STRUCTURE AT ALL LEVELS



VIII.RESULTS

The analysis table clearly indicates that there is a reduction in steel requirement in Fe500 as compared to Fe415.hence higher yield strength of steel contributes to minimization of steel. When we use **Fe500** instead of Fe415 in **beams** in R.C.C. Structure, it contributes around **17.91** % reduction in the steel reinforcement for the same section, same loading and same dimensions. Similarly, in case of **columns** of the R.C.C structure it contributes around **14.80 %** reduction in steel requirements. In the study presented in this project, we analysed the collected data from output file and the result of analysis which shows that both Fe415 and Fe500 fulfil the requirements of tensile strength and ductility up to a great extent in R.C.C. Structures. But on comparing in terms of percentage of steel requirement, Fe500 grade results in low consumption of steel apart from providing higher tensile strength. It helps in considerable savings in cost of the structure as well. In addition, it also reduces the weight of the structure. The design comparison of Fe415 and Fe500 grades of reinforcement bars involves various constraints and variability by the IS codes and functional requirements. Due attention must be given to the design components analysis while applying various constants and factors to the design parameter values. Small mistakes of the inputting irrelevant and wrong data results in inadequate design and may lead to failure of the structure.

Similarly, all ductility requirements as per is 13920-1993 must be adhered to before issue of structural drawing which is to be followed for execution. So the analysis indicates that Fe500 will be more suitable, more cost effective(30000 per ton) and suits to our requirement of the project. On the basis of analysis we may finalize Fe500 for the project.

IX.CONCLUSION

On analysing one hypothetical two storied framed structural project in seismic Zone IV with similar loadings and similar sizes of structural members for Fe415 and Fe500, we may conclude as follows:-

1. Both Fe415 and Fe500 provide high tensile strength.
2. There is lesser steel requirement for Fe500 grade of steel as compared to Fe415 grade of steel.
3. As steel requirement with Fe500 is less, the cost effectiveness with Fe500 grade of steel is much more than Fe415 grade of steel.
4. Keeping in view cost effectiveness of Fe500, it held advantage over Fe415 in all types of framed structures up to Zone IV. However, for buildings in Zone V area, the different characteristics specifically ductility characteristics of Fe415 and Fe500 must be evaluated before selecting.
5. The cost of Fe415and Fe500 are equal per kg, so the quantity of Fe500 being less than Fe415 makes Fe500 more economical.

X.SCOPE OF FUTURE STUDY

The yielding structural elements can advantageously be utilized to analyze the behavior of beams in terms of deflection for Fe415 & Fe500. It can also be used for analyzing comparison of sway of buildings and how buildings sway under different grades of steel. As the ductility of steel plays a vital role in sway especially in seismic prone zones, further study in this area may result in safe as well as cost effective structure.

Hence there is a lot of scope for further study. This may make structures safer, durable and economical.

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