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Variation in Poison's Ratio with Change in Grade of Concrete and Type of Steel Reinforcement

Swathy Krishnan B, Prakhar Duggal, Ravinder Kumar Tomar

Abstract: The structure that are widely used around the gold now days are mainly composite structure. These types of models or structures are used to make long span lower story heights and also to give extra stiffness. The past result shows that most of the collapses of buildings occur when the structure is struck with earthquake or seismic load. The poison's ratio is one of the most integral part which gives stability for the structure. In this research it is about the change is the poison's ratio that occurs with the change in percentage of steel and the grade of concrete in a reinforced concrete section. The variation in poisons ratio shows the variation in the stability of the structure. The study of the poisons ratio will help in a better practical design of the structure to prevent or the resist the structure from collapse during earthquake. In this paper we will see the experimental variation of the poisons ratio of column and we will analysis the behavior using software. Poison's ratio usually deals with the lateral strain and linear strain. This poisons ratio was found out by Simeon poison. It is one of the most important aspects in the design of any kind of structure.

Keywords: Poisons Ratio (PR), Composite Structure (CS), Lateral Strain, Linear Strain

I. INTRODUCTION

The PR for a concrete is usually taken in the range of 0.20 to 0.25. For high strength concrete it is from 0.1 to 0.2. The PR is defined as any direct stress is accompanied by a strain in its own direction are called linear strain and an opposite kind strain in every direction at right angle to it is called lateral strain. If water-cement is 0.4, however, the Poisson's ratio of the sample significantly changes [1]. This lateral strain bears a constant ratio is called as Poisson's ratio and it is denoted by (μ).

$$\text{Poisson's ratio } (\mu) = \frac{\text{LATERAL STRAIN}}{\text{LINEAR STRAIN}}$$

The PR for a composite material will be grater that the ratio considered for the individual elements as the combined stiffness will always account for the ratio. Low and medium strength concretes are the most commonly used concrete in the construction of civil engineering structures [2].

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* Correspondence Author

Swathy Krishnan B*, Post-Graduate student, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida-201313, India, Email: krishnanswathy8@gmail.com

Prakhar Duggal, Assistant Professor, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida-201313, India, Email: pduggal@amity.edu

Ravinder Kumar Tomar, Associate professor, Amity School of Engineering and Technology, Amity University Uttar Pradesh, Noida-201313, India, Email: rktomar@amity.edu

When it's a combined material it will always have an effect on the PR in this research paper we will find out the PR for a composite RCC column by changing its grade of concrete, percentage and type of steel reinforcement. So we can find out the difference in the PR and also compare its difference with the grade of concrete, percentage and type of the steel used. The basic principle of the composite material or the composite structure is based on the perfect or the partial cooperation between the steel and the concrete. The ratio of the steel and concrete should be optimum to have a greater efficiency. The effect of PR in a structure is such that column is the member the transfer the load to the foundation. So it's clear that the column that takes the lateral movement as well. From the above equation we can see that if the lateral strain can be increased the PR also gets increased, so that higher the PR higher will be stability of structure against earthquake. Under sustained and constant uniaxial stress loading, axial and transverse delayed strains are observed [3]. The thermal conductivity of ordinary concrete is high, and its thermal insulation performance cannot meet the requirements of building energy saving [4].

II. EXPERIMENTAL SETUP

2.1 Design of Column: Selected size of column as 230mmx230mmx550mm. Constraint of Universal Testing Machine (U.T.M) we have to restrict the length of the column to 550 mm. So we have selected section as 230x230x550mm According to I.S Code provision IS 456: 2000 (clause25.5.3.1 (a)) Minimum percentage of steel = 0.8% and Maximum percentage of steel = 4% . The grade of the concrete that was selected for the experiment is M20 and M25 grade concrete.

2.2 Selection of Steel Section: For the experimental work we select angle, normal and channel section. The cross sectional area of the column is kept constant and these types of reinforcement is used by changing the percentage of steel form 0.8% and 1% for each type of reinforcement.

The reinforced column with 0.8% steel is:

1. Normal steel section: 4 number of 12mm diameter bars
2. Angle steel section: 4 number of angle section 20mmx20mmx3mm
3. Channel steel section: 4 number of channel section 19mmx8mmx3mm

The reinforced column with 0.1% steel is:

1. Normal steel section: 5 number of 12mm diameter bars
2. Angle steel section: 4 number of angle section 25mmx25mmx3mm
3. Channel steel section: 6 number of channel 19mmx8mmx3mm

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In the current work, columns are reinforced with channel section, angle section, and normal reinforcement. A total 36 number of columns are casted with three specimens of each section viz. M20 with 0.8% and 1% Normal/Angle/Channel sections and M25 with 0.8% and 1% Normal/Angle/Channel sections.

Fig 1. Normal reinforcement for casting

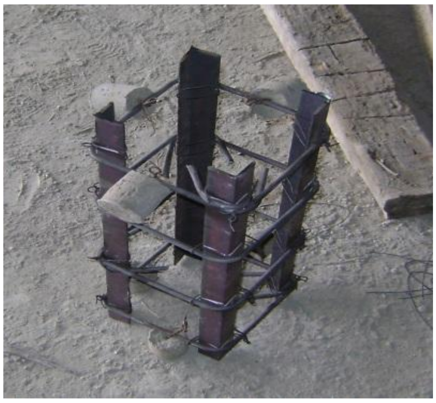

Fig 2. Angle reinforcement for casting

Fig 3. Channel reinforcement for casting

III. EXPERIMENTAL PROCEDURE

The procedure is done on a material testing lab. The UTM is the main device that is to be used for the procedure.

The composite columns are casted in the lab as per the above mentioned parameters it is taken and kept in a water tank filled with fresh water for seven days. After that the casted columns are taken for testing. Two gauges are attached to the columns on both sides of the columns before it's kept in universal testing machine (UTM). The gauge is fixed to find out the length of deformation of the column in both horizontal and vertical direction with the increase in the load that's being applied. The column is kept in UTM and the load is applied till the column fails. The specimen is kept vertically. With the obtained values we will find lout both lateral and linear strain and thus we get the PR for each of the columns. All the three different type of reinforced concrete columns are tested in the UTM and the results are noted

Table 1 Variation in the steel distribution

Sr. No.	Name of section	% of steel	% of steel
1	Normal R.C.C.	0.8	1
2	Channel	0.8	1
3	Angle	0.8	1

IV. RESULTS AND DISCUSSION

4.1 Dial gauge reading: The first testing was done on M20 grade concrete column with 0.8 percentage steel. In that case the maximum side ways deformation that was noted for normal reinforced column is 0.66mm and the highest linear deflection was obtained as 0.42mm.The maximum compression that was obtained was 6.1mm

In the second case that of the angle section column the maximum lateral side way deformation that was noted for angle reinforced column is 0.44mm and the highest linear deflection was obtained as 0.57mm. The maximum compression was 5.8mm

In the third case that of the channel section column the maximum side way deformation that was noted for channel reinforced column is 0.63mm and the highest linear deflection was obtained as 0.63mm. The maximum compression was 6.3mm

For the M25 grade concrete column with 1 percentage steel. In that case the maximum side way deformation that was noted for normal reinforced column is 0.98mm and the highest linear deflection was obtained as 1.89mm. The maximum compression was 5mm.

In the second case that of the angle section column the maximum side way deformation that was noted for angle reinforced column is 0.56mm and the highest linear deflection was obtained as 0.7mm. The maximum compression was 4.8mm.

In the third case that of the channel section column the maximum side way deformation that was noted for channel reinforced column is 0.9mm and the highest linear deflection was obtained as 0.48mm. The maximum compression was 4.2mm.

All these values were noted as there are the most important data that will eventually lead us in finding the PR value, so all these value are to be noted with at most accuracy.

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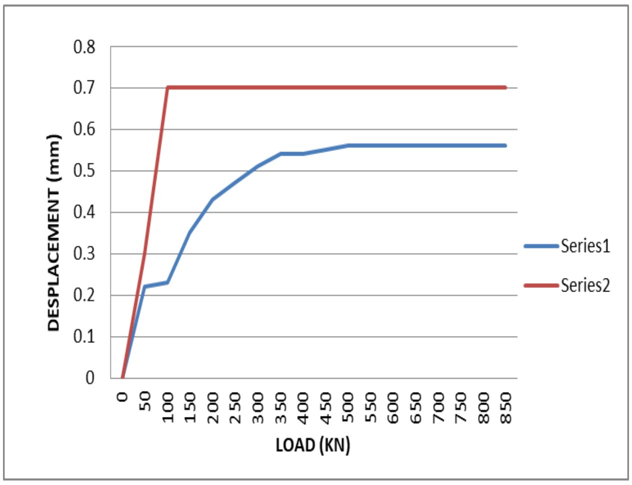

Fig 4 Lateral and linear deformation of M25 grade column with 1% angle section reinforcement

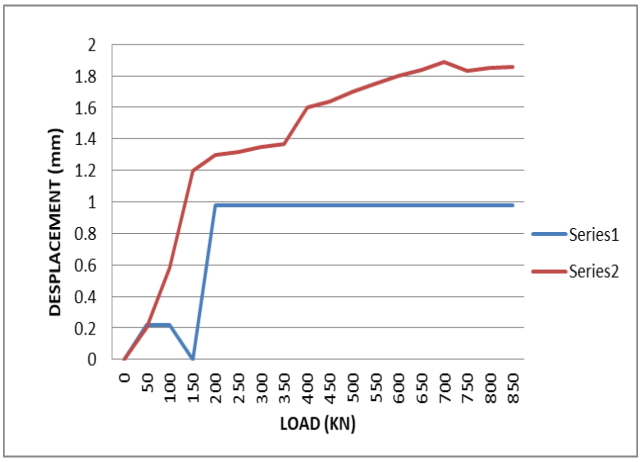

Fig 5. Lateral and linear deformation of M25 grade column with 1% normal section reinforcement

These two graphs show the displacement in both lateral and linear direction of the load applied. From this graph we can find that the displacement in the direction of the load will always be greater than the displacement in the lateral direction. The red line shows the linear displacement with increase in load and the blue line shows the lateral displacement

4.2 Lateral and Linear strain: To find lateral strain both the highest lateral and linear deformation for each type was added and was divided by 230mm which is the horizontal dimension of the column. For the linear strain the highest compression will be divided by the height of the column which is 550mm.

Lateral strain = $\frac{sum\ of\ lateral\ and\ linear\ \mathrm{def}}{230(\mathrm{mm})}$

Linear strain = $\frac{compression(\ mm)}{550(\mathrm{mm})}$

Thus the obtained lateral and linear stress are as given

Table 2 The lateral stress and lateral strain for M20 grade concrete and 0.8% steel

Sr. No.	Name of section	Lateral strain	Linear strain
1	Normal R.C.C.	0.0047	0.0111
2	Angle	0.0044	0.0105
3	Channel	0.005	0.0115

Table 3 The lateral stress and lateral strain for M25 grade concrete and 1% steel

Sr. No.	Name of section	Lateral strain	Linear strain
1	Normal R.C.C.	0.0125	0.0091
2	Angle	0.0055	0.0087
3	Channel	0.006	0.0076

From the above two table we can conclude that the lateral strain increases with the increase in percentage of steel and grade of concrete but the linear strain decrease with the increase in percentage of steel and grade of concrete.

4.3 Poisons Ratio (μ): It is the ratio of lateral strain divided by linear strain. Poisson´s ratio can be defined as the negative ratio of strains perpendicular to the load direction to the strains parallel to the loading direction [5]. By knowing both lateral and linear strain we can find out the PR using the formula

Poisson's ratio (μ) = $\frac{\text{LATERAL STRAIN}}{\text{LINEAR STRAIN}}$

Table 4 The PR for different types of column

Sr. No.	Name of section	M20 grade concrete with 0.8%steel	M25 grade concrete with 1%steel
1	Normal R.C.C.	0.423	0.7285398
2	Angle	0.416	1.5930736
3	Channel	0.44	1.2727273

From the table it is found that the poisons ratio increases with increase in the percentage of steel and the grade of concrete. As there is huge difference in the values for each of the type it is better to take the average for each type to avoid the variation. So the poisons ratio for M20grade concrete with 0.8% steel will be 0.426. The poisons ratio for the columns with M25 grade concrete and 1% steel reinforcement is taken as 0.773871115.The values are obtained by taking the average from each section .

V. SOFTWARE VALIDATION

The computer analyses will always provide us with the most accurate results. So we will use staad pro software to analyze a frame structure by providing the PR value that was obtained by our experimental work.

For that we have formed a bay frame with fixed supports. The column and beams are of size 0.23m*0.23m rectangular columns and beams. The grade of the concrete was provided as M25 and the percentage of steel was provided as 1%.

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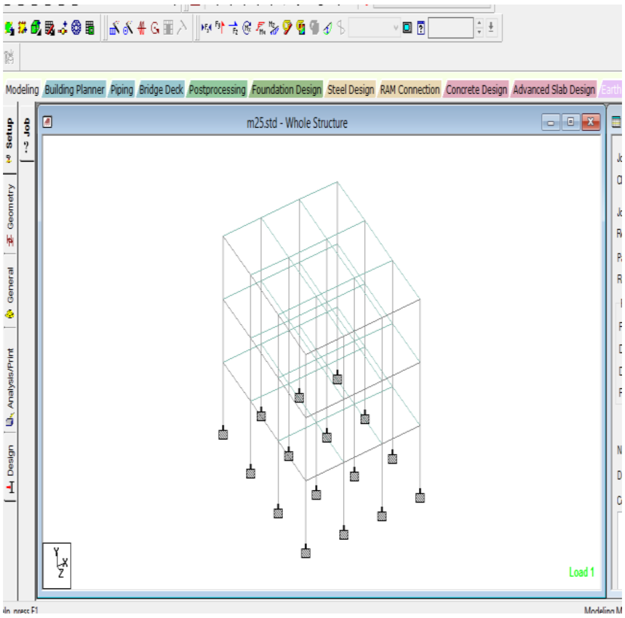

Fig 6 .The 3D view of the modeled frame

To give the poisons ratio we have to add a new material in the material section and provide the value of PR as our experimental value which is 0.773871115 which was made 0.78 and give other all value as per the values given in the software. In the loading section both live load and dead load was provided.

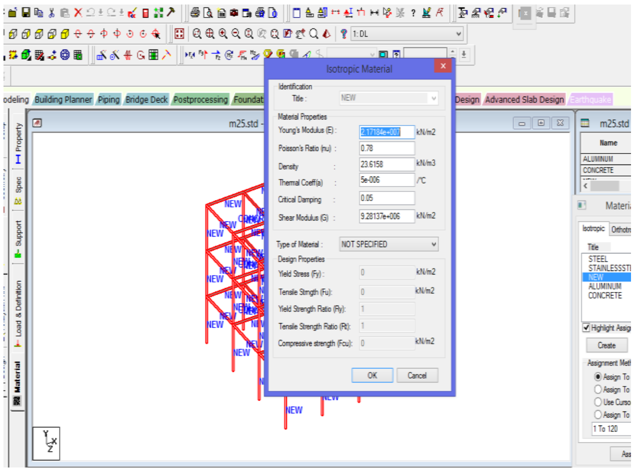

Fig 7.Inserting The PR value by creating new material

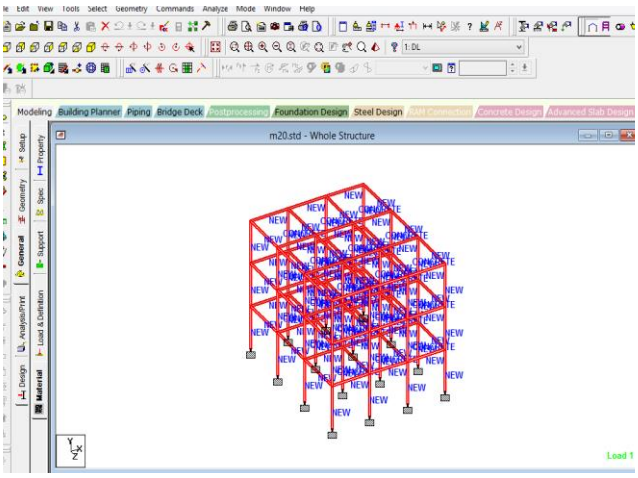

Fig 8.Assigning the new material to all structural members

The structure so made was the analyzed and the structure was shown safe during the analysis giving all the results which shows the value that we found out by experimentation is correct.

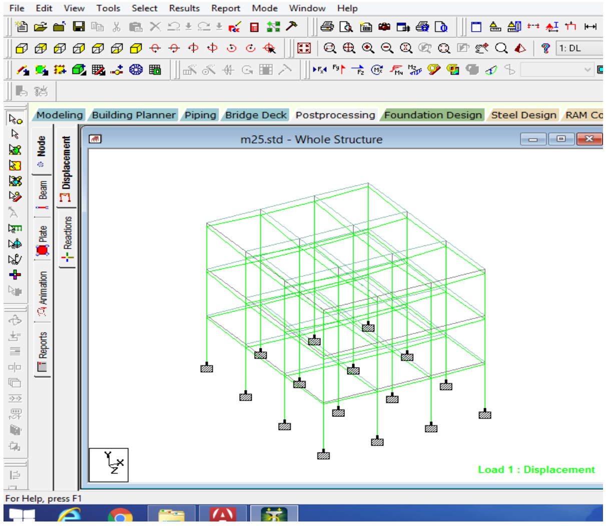

Fig 9.3D view of the frame after analysis

VI. CONCLUSION

From this experiment we can conclude the facts that the PR ratio increases with the increase in the grade of the concrete and the percentage of steel. The most important observation is that the lateral strain increases with the increase in the grade and percentage of steel and also the linear strain decreases at the same time, which means that it provides more stability to the structure during earthquake. PR is one of the major components in the design of member. So from this experiment we can see the difference the PR, which actually is beneficial in design of some individual members or structure as a whole. It also helps in us in designing the structures in such a way that the structure during the earthquake is able to absorb more energy by deforming more without failing.

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AUTHORS PROFILE

Dr. R.K. Tomar, did his B. Tech in Civil from Pune and his Masters from DTU. He later received his Ph.D. from the Indian Institute of Technology (IIT) Delhi and is currently, Head of the Department of Civil Engineering, Amity School of Engineering and Technology, Amity University, India. His research interests include artificial intelligence applications in buildings and sustainable built environment. He has a combined experience of 30 years in industry and academia in various capacities. He has published several research articles in international peer-reviewed journals. He is also guiding students for Ph.D. in the field of Energy and Built Environment.

Mr. Prakhar Duggal, did his B. Tech in Civil and M. Tech in Structural Engineering with distinction throughout. He has teaching experience of over 8 years and is currently associated with Amity School of Engineering Technology, Amity University Uttar Pradesh. He has participated in various national and international conference and currently has 12 Scopus indexed publications to his name and several research articles in in peer-reviewed journals. His research interests include construction materials applications in buildings, sustainable built environment and devices and strategies for greening the buildings. He has also successfully guided 5 M.Tech theses and more than 50 UG research projects

Mr. Swathy Krishnan, B did his B Tech in civil engineering from kerala Calicut University and he is currently perusing his M tech in Amity University Noida India. He has published a review paper in IEEE journal. He has attended many international conferences and national level seminars. He also has 1 year industrial experience. He has done internship in DMRC kochin and also in a consultancy in Oman. His research interests include construction materials applications in buildings.

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