

Stress Strain Behaviour of Confined Normal Grade Concrete

Kalluru.Rajasekhara

M.Tech student, IV semester, Visvodaya Engineering College, Kavali, India.

M.Praveen Kumar

Professor, Department of Civil Engineering, Visvodaya Engineering College, Kavali, Andhra Pradesh, India.

Abstract – The concrete using in the civil engineering structures generally have low tensile properties compared to the reinforced concrete. In order to attain high strength and properties, here we are going to test the behaviour of the reinforced concrete using hoops.

An experimental investigation into the behaviour of circular, confined, reinforced concrete columns was undertaken. Thirty 150 mm diameter, 300 mm high units were cast with varying amounts of longitudinal and lateral steel.

These were subjected to concentric or eccentric axial loads to failure at slow or dynamic loading rates. Confinement requirements of reinforced concrete columns are discussed and the results and analyses of experimental work presented. Results include an assessment of the significance of loading rate, eccentricity, amount and distribution of longitudinal steel, and the amount of confining steel.

A general stress-strain curve for circular concrete sections loaded at seismic rates is proposed and compared with existing curves based on previous static loading tests.

Knowledge of the stress-strain curve for confined concrete is particularly important for columns with high axial load levels, when the moment curvature characteristics of the column are largely dependent on the concrete compressive strength and the stress strain relationship.

The testing was generally carried out in load controlled testing machines at slow loading rates. Behaviour under these conditions has been used to predict behaviour under seismic conditions, which are characterized by displacement control, rapid loading rates, repeated load application, and eccentricity of loading, recently more realistically sized units have been used but not under simulated seismic conditions.

Index Terms – Stress Strain, Concrete, Eccentric Axial Load.

1. INTRODUCTION

Concrete is a building material in the human history. It consists of Cement, Aggregates and Water. It is no doubt that with the improvement of human civilization concrete will continue to be a governing construction material in the future.

The most widely used construction material in the world is probably the concrete. It is only second to water as the most

profoundly consumed substance with about six billion tons being produced every year. There are many types of concrete designed to suit a variety of purposes coupled with a range of compositions and performance characteristics.

The mixture forms a fluid mass when aggregate is mixed together with dry Portland cement and water, then that is easily molded into shape. Often, additives (like super plasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Concrete is poured with reinforcing materials embedded to provide tensile strength, yielding reinforced concrete.

Many types of concrete are available, distinguished by the proportions of the main ingredients below.

Aggregates consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone or granite, along with finer materials such as sand.

Cement most commonly Portland cement is associated with the general term "concrete." A range of materials can be used as the cement in concrete.

Water Combining with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

1.1 Confined concrete:

When concrete is subjected to a uni-axial load (for example in Columns) while having transverse reinforcement like circular hoops or a helical spring then that is called Confined Concrete. So here what you need to know is that the load is perpendicular to the direction of the reinforcement which makes the concrete confined.

Concrete which has closely-spaced special transverse reinforcement, which restrains the concrete in directions perpendicular to the applied stress.

Advantages:

1. The confined concrete has less axial deformation in comparison in the unconfined concrete when subjected to the same amount of load.
2. The failures will initiate from the development of deformation in steel sheet at top and bottom portion of the column of the structure when the ultimate load is applied the deformation initiates in the middle portion.
3. Large span of columns can be adopted
4. High modulus of elasticity for effective long-term reinforcement even in the hardened concrete

Disadvantages:

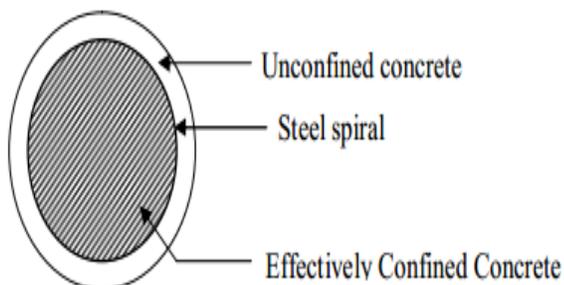
1. Greater reduction of workability
2. High cost of materials
3. Requires skilled labour

1.2 Stress-strain curves of concrete members:

The relationship between the stress and strain that a particular material displays is known as that material's stress-strain curve. This curve is unique for each material and is found by recording the amount of strain or deformation at distinct intervals of stress, with respect to the original specimen's cross-sectional area and length. These curves reveal the material's important properties such as the modulus of elasticity (E), yield stress (in metallic materials), ultimate strength, and ultimate strain, but more importantly is the fundamental information required for advanced engineering applications, such as moment-curvature analysis which shows an indication of the available flexural strength and ductility.

Circular section

The circular section can be idealized into the same of effectively confined concrete, steel spiral and unconfined concrete as shown in the below figure.

**Rectangular section**

In this case, the concrete is longitudinally contracted and laterally expanded with internal micro-cracks as the axial load is increased from the initial stages of loading. The transverse

reinforcement resists the high expanded pressure, and the effective confinement by the lateral ties leads to the enhancement of the axial load-carrying capacity.

1.3 Uses of stress strain behaviour of concrete:

The uses of stress strain behaviour of a concrete are:

1. The stress strain behaviour is used to know the concrete properties like young's modulus or modulus of elasticity of concrete, ductility.
2. It is used to determine the Poisson's ratio.
3. The breaking point load can be determined using the stress strain analysis.
4. The ultimate strains and stresses can be known at different load conditions.

1.4 OBJECTIVES OF THESIS

With a general understanding of the superior stress-strain behavior displayed by active confinement to be obtained, a new and innovative method to confine concrete specimens will be discussed and further investigated within this thesis.

Within this thesis all relative information with regards to the confining potential will be further investigated in great detail, and the following overall primary objectives have been selected.

The precise objectives of the study are as follows:-

To study the stress strain behaviour of concrete using 4mm diameter steel bars confining with hoops at 28 days curing age for different grades of concrete like:

1. M20 grade concrete using 4 mm diameter steel bars of 6 numbers placed in cylinder confining with 3, 4 and 5 hoops of 1.5 mm diameter.
2. M25 grade concrete using 4 mm diameter steel bars of 6 numbers placed in cylinder confining with 3, 4 and 5 hoops of 1.5 mm diameter.
3. M30 grade concrete using 4 mm diameter steel bars of 6 numbers placed in cylinder confining with 3, 4 and 5 hoops of 1.5 mm diameter.

2. MATERIALS PROPERTIES**2.1 Ordinary Portland cement**

Portland cement is the most common type of cement in general usage around the world. It is a basic ingredient of concrete, mortar, and plaster. A number of types of Portland cement are available with the most common being called ordinary Portland cement which is grey in color, but a white Portland cement is also available. The specific gravity of cement is 3.14.

2.2 FINE AGGREGATE

Fine aggregate/sand is an aggregation of grains of mineral matter got from the breaking down of rocks. The fine total was

going through 4.75 mm strainer and the evaluating zone of fine total was zone II according to Indian Standard particulars e grains or particles, yet it is unmistakable from dirt's which contain natural materials. Specific Gravity-2.75, Fineness Modulus-2.8

2.3 COARSE AGGREGATE

Coarse Aggregates are the pulverized stone is utilized for making concrete. The stone is quarried, pounded and evaluated. Machine smashed rock softened stone precise up shape was utilized as coarse aggregate was 20 mm and Specific Gravity-2.63, Fineness Modulus-7.2

2.4 WATER

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

3. MIX DESIGN OF CONCRETE

Table: Mix proportion for M20:

Water	Cement	Fine agg.	Coarse agg.
191.58 lit	426kg	583kg	1158kg
0.45	1	1.37	2.71

Table: Mix proportion for M25:

Water	Cement	Fine agg.	Coarse agg.
191.6 lit	479kg	603kg	1094kg
0.40	1	1.25	2.28

Table: Mix proportion for M30:

Water	Cement	Fine agg.	Coarse agg.
191.6 lit	497.6kg	580kg	1101kg
0.385	1	1.16	2.21

4. EXPERIMENTAL RESULTS

4.1 Stress strain test:

To determine the stress strain behaviour of a confined concrete, we need the stress strain setup. The cylinder which is placed in the setup is shown in the figure.



Stress-strain setup for cylinder

The dial gauge reading is placed for the setup to take the readings in order to calculate the strain. After the completion of setup, the cylinder is to be placed in the compressive testing machine as shown in the fig.



Placing of cylinder in the compressive testing machine

After placing of cylinder in the testing machine, the load is to be applied gradually and the readings should be noted from the dial gauge corresponding to the load. After increasing the load gradually, the failure of cylinder will occurs. The cylinder at which the failure occurs is noted as the breaking load. At the failure of cylinder, the readings of the dial gauge will increased but the load will decreased. The failure of cylinder under the load is shown in the below figure.

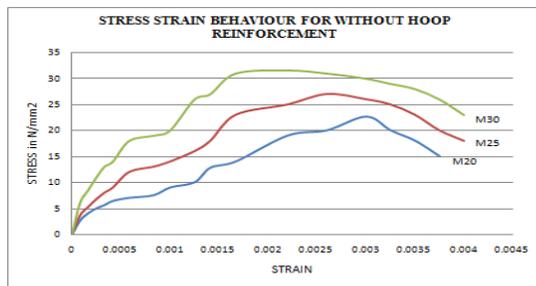


Failures of cylinder

4.2 FINAL TEST RESULTS AND DISCUSSIONS

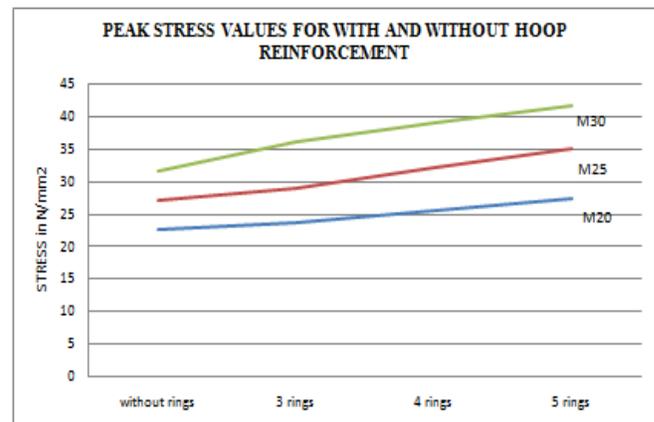
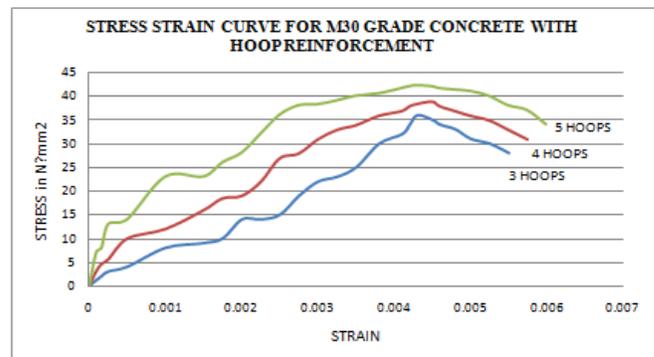
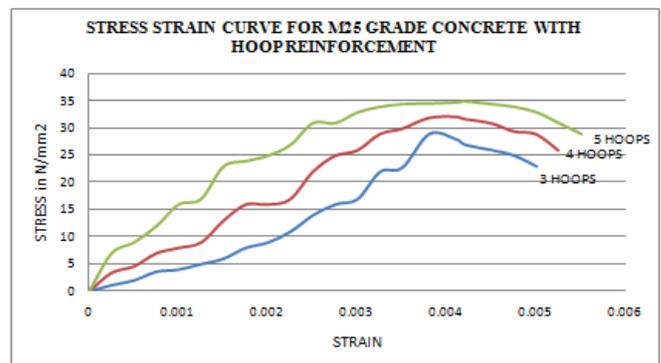
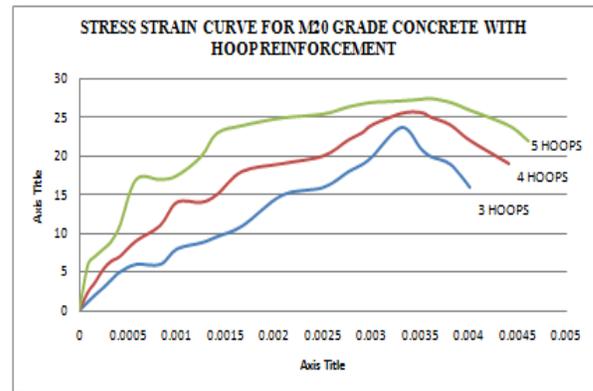
Determination of stress strain test for M20, M25, M30 grade concrete

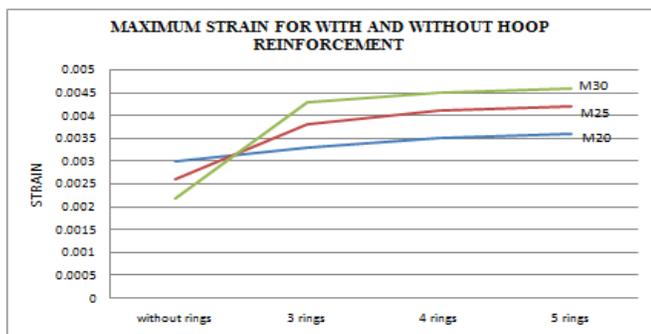
Stress =Load/Area (N/mm ²)	Strain=deformation/ original length
0	0
2.829	0.00083
4.527	0.00016
5.658	0.00025
6.2	0.00033
7.92	0.000416
9.62	0.000583
11.317	0.00083
12.449	0.00100
13.60	0.00125
14.712	0.00141
16.976	0.00167
19.805	0.00200
21.503	0.00250
22.635	0.0030



Stress strain test for M20 grade concrete with hoop reinforcement

Stress=Load/Area (N/mm ²)	Strain=deformation/ original length
0	0
1.1317	0.000083
2.263	0.00016
3.395	0.00025
4.527	0.00033
5.658	0.000416
6.790	0.00050
7.922	0.000583
9.054	0.000670
10.185	0.000750
11.317	0.000830
12.449	0.00100
13.580	0.00108
14.712	0.00125
15.844	0.00150
16.976	0.00183
18.67	0.00200
20.37	0.00225
21.00	0.002416
21.87	0.00267
22.40	0.00291
22.98	0.003
23.8	0.0033





4.3 DISCUSSIONS:

ULTIMATE STRESS:

For Plain Concrete:

For M20 grade concrete, the ultimate stress occurs at 22.635 N/mm².

For M25 grade concrete, the ultimate stress occurs at 27 N/mm².

For M30 grade concrete, the ultimate stress occurs at 31.6 N/mm².

For Reinforced Concrete:

For M20 grade concrete using 4 mm diameter bars confining with 3 hoops, we have attained the ultimate stress at 23.8 N/mm².

Similarly, with 4 hoops the ultimate stress is 25.6 N/mm² and with 5 hoops the ultimate stress is 27.4 N/mm²

For M25 grade concrete using 3 hoops, we have attained the ultimate stress at 29 N/mm².

Similarly, with 4 hoops the ultimate stress is 32.2 N/mm² and with 5 hoops the ultimate stress is 35 N/mm²

For M30 grade concrete using 3 hoops, we have attained the ultimate stress at 36 N/mm².

Similarly, with 4 hoops the ultimate stress is 39 N/mm² and with 5 hoops the ultimate stress is 41.6 N/mm²

From the results, we can conclude that by increasing the rings for reinforced concrete the ultimate stress is also increasing.

The ultimate stress for reinforced concrete is increased by around 30% compared to the plain concrete.

YOUNG'S MODULUS:

By finding the slope from the graph, we can obtain the young's modulus.

For Plain Concrete:

The young's modulus for M20 grade concrete is $E=40000$ N/mm²

The young's modulus for M25 grade concrete is $E=42000$ N/mm²

The young's modulus for M30 grade concrete is $E=44000$ N/mm²

For Reinforced Concrete:

The young's modulus for M20 grade concrete with 3 rings is $E=48000$ N/mm²

The young's modulus for M20 grade concrete with 4 rings is $E=50000$ N/mm²

The young's modulus for M20 grade concrete with 4 rings is $E=52000$ N/mm²

The young's modulus for M25 grade concrete with 3 rings is $E=54000$ N/mm²

The young's modulus for M25 grade concrete with 4 rings is $E=56000$ N/mm²

The young's modulus for M25 grade concrete with 5 rings is $E=58000$ N/mm²

The young's modulus for M30 grade concrete with 3 rings is $E=60000$ N/mm²

The young's modulus for M30 grade concrete with 4 rings is $E=62000$ N/mm²

The young's modulus for M30 grade concrete with 5 rings is $E=64000$ N/mm²

The young's modulus for the reinforced concrete is increased by 40% compared to the plain concrete.

MAXIMUM STRAIN:

For Plain concrete:

For M20 grade concrete, the maximum strain is obtained at 0.003

For M25 grade concrete, the maximum strain is obtained at 0.0026

For M30 grade concrete, the maximum strain is obtained at 0.002

For Reinforced Concrete:

For M20 grade concrete using 3 hoops, the maximum strain is obtained at 0.033

Similarly, with 4 hoops the maximum strain is 0.0035 and with 5 hoops the maximum strain is 0.0036

For M25 grade concrete using 3 hoops, the maximum strain is obtained at 0.0038

Similarly, with 4 hoops the maximum strain is 0.0041 and with 5 hoops the maximum strain is 0.0042

For M30 grade concrete using 3 hoops, the maximum strain is obtained at 0.0043

Similarly, with 4 hoops the maximum strain is 0.0045 and with 5 hoops the maximum strain is 0.0046

From the results, we can conclude that the maximum strain for the reinforced concrete is increased by 50% compared to the plain concrete.

Stress strain behaviour:

The pattern of stress-strain behavior for medium strength conventional concretes (M20, M25 and M30 grades) is approximately same except the small variations in the peak stresses and strains corresponding to the peak stress values.

When the hoop reinforcement is used for M20, M25 and M30 grades, the pattern of stress-strain behavior is similar to the conventional concrete of medium grades except the increase in peak stress values and increase in strain corresponding to the peak stress values.

5. CONCLUSION

1. From the results, we have studied the stress strain behaviour of a plain concrete and confined normal grade concrete with hoops under axial compressive load.
2. The results shows that the stress-strain behaviour in the case of using hoops shows a similar pattern except in increase in the peak stress values compared to the normal plain concrete.
3. The circular columns confined with hoop reinforcement generally performed better than the normal rectangular and square columns.
4. The load taking on to the concrete using hoops gives breaking load of more than 30% compared to the normal plain concrete.
5. From the results, we have attained the young's modulus of more than 40% for the reinforced concrete compared to the plain concrete.
6. From the results, we have obtained the maximum strain increased by almost 50% in case of reinforced concrete than the normal plain concrete.
7. By increasing the number of hoops to the reinforced concrete, the compressive stresses are also increased slightly by almost 10%.

REFERENCES

- [1] Attard, M. M., Setunge, S., 1996. "Stress-strain relationship of confined and unconfined concrete". Material Journal ACI, 93(5), 432-444
- [2] Braga, F., Gigliotti, R., Laterza, M., 2006. "Analytical stress-strain relationship for concrete confined by steel stirrups and/or FRP jackets". Journal of Structural Engineering ASCE, 132(9), 1402-1416.
- [3] D'Amato M., February 2009. "Analytical models for non linear analysis of RC structures: confined concrete and bond-slips of longitudinal bars". Doctoral Thesis. University of Basilicata, Potenza, Italy.
- [4] D'Amato, M., Braga, F., Gigliotti, R., Kunnath S., Laterza, M., 2012. "A numerical general-purpose confinement model for non-linear analysis of R/C members". Computers and Structures Journal, Elsevier, Vol. 102-103, 64-75.
- [5] Karsan, I. D., Jirsa, J. O., 1969. "Behavior of concrete under compressive loadings", Journal of Structural Division ASCE, 95(12), 2543-2563.
- [6] Heo-Soo C., Keun-Hyeok Y., Young-Ho L. & Hee-Chang E. "Stress-strain curve of laterally confined concrete", Eng. Struct 24, 2002, 1153-1163.
- [7] Reddiar M. K. M. "Stress-strain model of unconfined and confined concrete and stress-block parameters", Master of Science Thesis, Texas A & M University, U.S.A, 2009.
- [8] Computer and Structures Inc., "Technical Notes - Materials stress - strain curves", California, 2008.
- [9] "PART iv, Design foundations, Design specifications of road bridges (1991), Japan Road Association Fuji, M. et al (1988)." A study on the application of a stress -strain relation of confined concrete. JCA proceedings of cement and concrete, Japan Cement Association, vol.42, Tokyo, Japan, pp.311-314.
- [10] Mander, J.B., Priestley, M.J.N and Park, R.(1988a)." theoretical stress-strain model for confined concrete." Journal of the Structural Division, ASCE, Vol.114, No.ST8, pp.1804-1826.
- [11] Muguruma.H.etal. (1978), "ductility of square confined concrete columns". Journal of the Structural Division, ASCE, Vol.108, No.ST8, pp.929-950.

Authors



Kalluru.Rajasekhar awarded B.Tech Degree with the specialization of Civil Engineering from Visvodaya Engineering College, Kavali. At Present pursuing M.Tech Degree in Structural Engineering at Visvodaya Engineering College, Kavali.



M.Praveen Kumar awarded B.Tech Degree with the specialization of Civil Engineering. And awarded M.Tech Degree with the specialization of Structural Engineering... At Present working as Assistant Professor at Visvodaya Engineering College, Kavali.