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Effect of Aggregate Grading and Cementitious By-product on Performance of Pervious Concrete

Husain N Hamdulay, Roshni J John, D.R.Suroshe

PG Student, Dept. of Civil Engineering, Saraswati College of Engineering, Kharghar, India.

Head, Dept. of Civil Engineering, Saraswati College of Engineering, Kharghar, India.

Principal, Revera Institute of Technology, Kharghar, India

ABSTRACT: In India the rainwater on the streets and parking's on asphalt and conventional concrete pavement generally lead to water logging and the also run-off water from various sources go in streams or nallahs. Pervious concrete should be chosen for its obvious environmental benefits. As environment is concerned, carbon dioxide emission from Portland cement production is significant. Therefore, by partially replacing the cement with industrial by-product, such as fly ash and slag which have been used successfully as supplementary cementitious materials. The change in properties of pervious concrete due to size of aggregates used is being assessed in this project. The concrete is assessed for its Compressive Strength, Split Tensile Strength, Permeability and flexural strength. The results are interpreted based on graphs obtained.

KEYWORDS: Pervious concrete, Flyash, GGBS, falling head permeability.

I. INTRODUCTION

Pervious concrete is considered a sustainable building alternative for concrete and/or asphalt pavement parking lots because it provides pollution mitigation and storm water management. Pervious concrete acts as a filtration device for storm water and turns the entire parking area, pathway, or other paved surface into a retention treatment basin. Storm water can flow through the pavement to the subgrade underneath, taking with it pollutants that would typically end up in municipal storm water systems. Naturally occurring soil microbes then store and break down the pollutants, preventing aquifer pollution.

Advantages of Pervious Concrete

- The benefits of pervious concrete are not limited to its infiltration capacities.
- A number of studies have shown its potential to remove pollutants from water,
- Decreasing flooding possibilities, especially in urban areas and reducing puddles on the road
- Reduce noise, improve skid resistance, and
- Help mitigate the heat island effect
- It returns rain water to the ground, recharging ground water and aquifers
- The runoff from paved areas is reduced, which reduces the need for separate storm water retention
- Supporting vegetation growth

II. RESEARCH SIGNIFICANCE

Evaluating the performance of pervious concrete using locally available aggregates is important for use in local regions. Moreover using supplementary cementitious material changes the properties of concrete mix which may lead to variation in strength properties as well as the porous structure of the concrete hence it has to be assessed.

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III. MATERIAL USED

- **Cement**

Ordinary Portland cement of 53-grade will be used in this study conforming to IS: 8112-1989 having Specific gravity 3.15.

- **Aggregates**

The coarse aggregate passing through 20 mm and retained on 10 mm sieve was used in research. Aggregates of size 10 mm and 20 mm used in the project will be local angular aggregates available with distributor.

- **Ground Granulated Blast Furnace Slag (GGBS)**

The GGBS used in research was obtained from JSWSteel Plant. The specific gravity of about GGBS is 2.88.

- **Fly ash (FA)**

Fly ash required for the project was obtained from local fly ash brick manufacturer having its source from Nasik Thermal Power Plant having a specific gravity of 2.15.

- **Admixtures**

Water Reducing Admixtures is being used for preparing the pervious concrete mix. BASF admixtures Master Polyheed 8650 was used for the purpose.

- **Water**

Water quality used in pervious concrete should be the same as that used in conventional concrete: potable water, recycled water from the concrete industry, or tap water. Due to the sensitivity of pervious concrete, water quality control is very important.

IV. MIX PROPORTION

Trial concrete mixes shall be prepared keeping water to cementitious material ratio (W/C_m) constant for all the six concrete mixes. The design mix proportions are as follows:

Table 1 Mix Proportions for Pervious Concrete Mixes

Mix Composition	Mix Abbv	Quantity (Kg/m^3)						
		Cement	Fly Ash	GGBS	Water	CA10	CA20	Admixture
C:FA/GGBS = 100:0	PM 1	300	0	0	100	1780	0	1
C:FA/GGBS = 100:0	PM 2	300	0	0	100	712	1068	1
C:FA = 85:15	PM 3	255	45	0	100	1780	0	1
C:FA = 65:35	PM 4	195	105	0	100	1780	0	1
C:GGBS = 75:25	PM 5	225	0	75	100	640	960	1
C:GGBS = 50:50	PM 6	150	0	150	100	640	960	1

C: Cement; FA: Fly Ash; GGBS: Ground Granulated Blast Furnace Slag

V. EXPERIMENTAL PROGRAMME:

As part of project 6 samples of pervious concrete were prepared. Practical preparation of concrete mixes for various concrete/ aggregate mix proportions, use of admixtures was done

Proportion 1- Use of only 10 mm aggregates (PM 1)

Proportion 2- Mix proportion of 10 mm and 20 mm aggregates (PM 2)

Proportion 3- Higher strength mix (From above) + Fly ash (15 %) (PM 3)

Proportion 4- Higher strength mix (From above) + Fly ash (35 %) (PM 4)

Proportion 5- Higher strength mix (From above) + GGBS (25 %) (PM 5)

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Proportion 6- Higher strength mix (From above) + GGBS (50 %) (PM 6)

The basis of mix design was based on trial and error method as no exact design method is available for mix design of pervious concrete.

VI. TESTING METHODS AND PROCEDURES

All the six concrete mixes were tested for

- A. Compressive strength at 3, 7 & 28 days following the guidelines of IS 516,
- B. Flexure test for beams at 28 days,
- C. Split tensile test for cylindrical molds at 28 day
- D. Water Permeability test at 28 days



Fig 2 (a) Compressive strength and flexure strength testing of Pervious sample

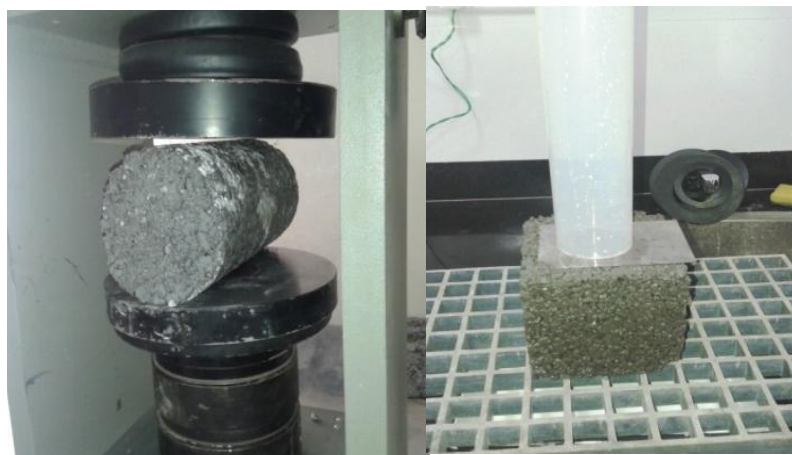


Fig 2 (b) Split Tensile and Falling Head Permeability Testing of pervious concrete specimen

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VII. EXPERIMENTAL RESULTS AND DISCUSSION

Compression Test and Density

Table1 Results for Compressive Strength and Density of Pervious Mixes

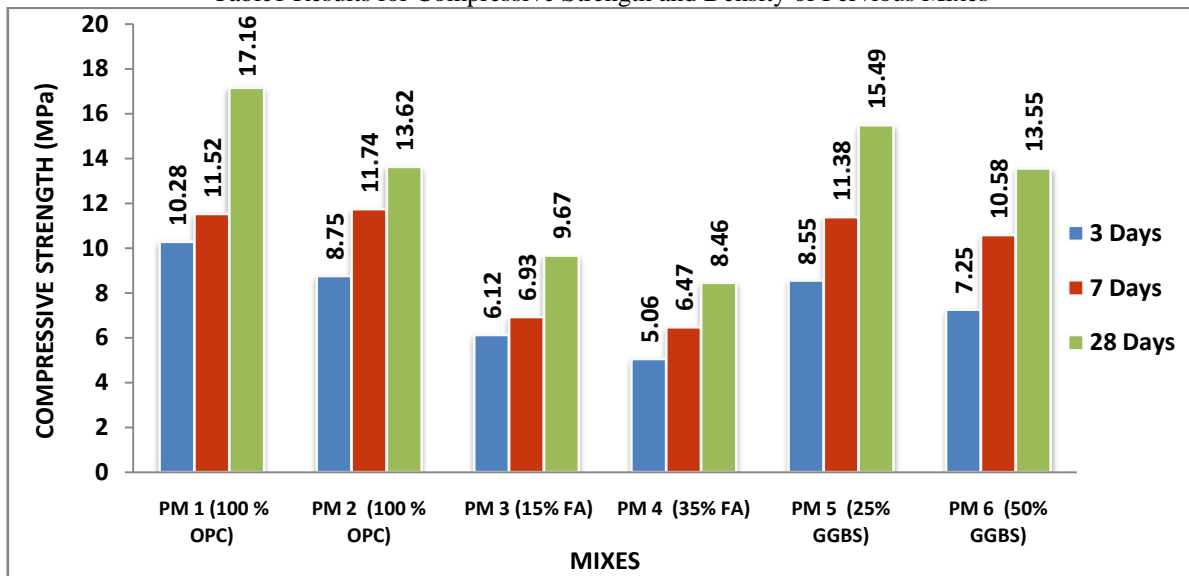


Fig 1 -3, 7 & 28 days Compressive Strength for different Mixes

The mean value of the 28 days compressive strength of pervious concrete with 100% cement had 17.16 MPa for 10mm aggregate and 13.62 MPa for mix of 10 and 20mm aggregate. As expected, pervious concrete resulted in 26% low compressive strength due to its higher porosity. At the same age, pervious concrete with 15% fly ash had the strength of 9.67 MPa, while the strength of pervious concrete with 35% fly ash had strength of 8.46 MPa, which is only 55.4% and 48% respectively of the 100% OPC. When cement replaced with GGBS with 25% and 50% variation gave 28 days strength of 15.49 MPa and 13.55 MPa respectively which is 10.78% and 26.64% less than 100% OPC respectively. All concrete mixes showed improvement in strength with the increase in the age. The strength of pervious concrete with Flyash showed low strength development from 14 to 28 days.

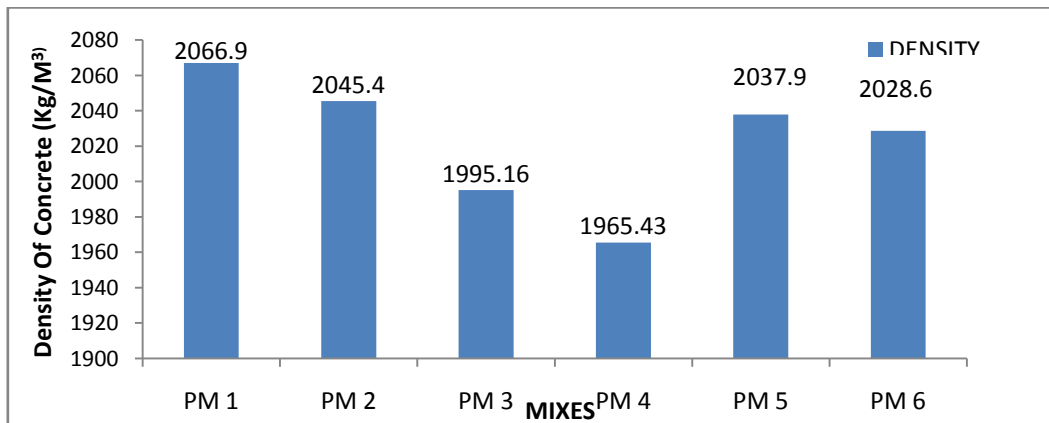


Fig 3 Density of various pervious mixes

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The mean density for conventional concrete varies between 2400 and 2500 kg/m³, while pervious concrete has a density between 1965 and 2067 kg/m³. Therefore, the pervious concrete showed nearly 21-27% lower density than conventional concrete.

Split Tensile Strength

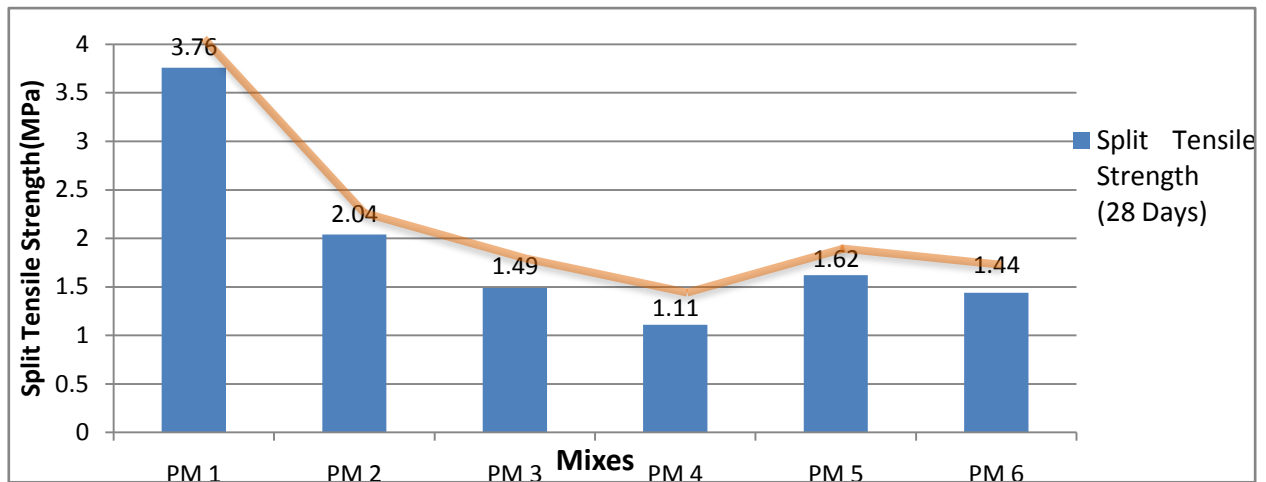


Fig 4 28 Days Split Tensile Strength for Different mixes

The split tensile strength for 100% OPC with 10 mm aggregates showed strength of 3.76MPa. For mix PM 2 the strength reduced by 45.7% after using a combination of 10mm and 20mm aggregates. When tested for samples containing flyash and compared to 100 % OPC with PM 1 mix the strength was only 39.6% and 29.5% for PM 3 and PM 4. The mix containing GGBS showed greater strength than FA but 43% and 38.3% strength of PM 1 mix.

Flexure Test

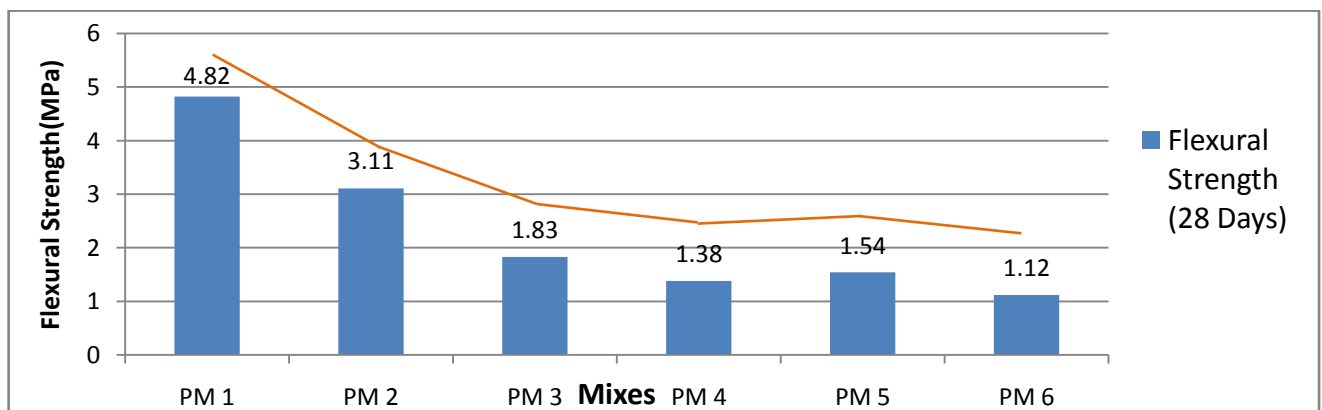


Fig 5 28 Days Flexural Strength for Different mixes

Permeability

The calculations for finding the permeability coefficient by falling head test are as below

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$$r_{eff} = \frac{r_1 + r_2}{2} = \frac{3.4 + 7.5}{2} = 5.45 \text{ cm}$$

$$A_{eff} = \pi r_{eff}^2 = \pi \times 5.45^2 = 93.313 \text{ cm}^2$$

$$k_p = \frac{V}{A_{eff} \times (t_2 - t_1)}$$

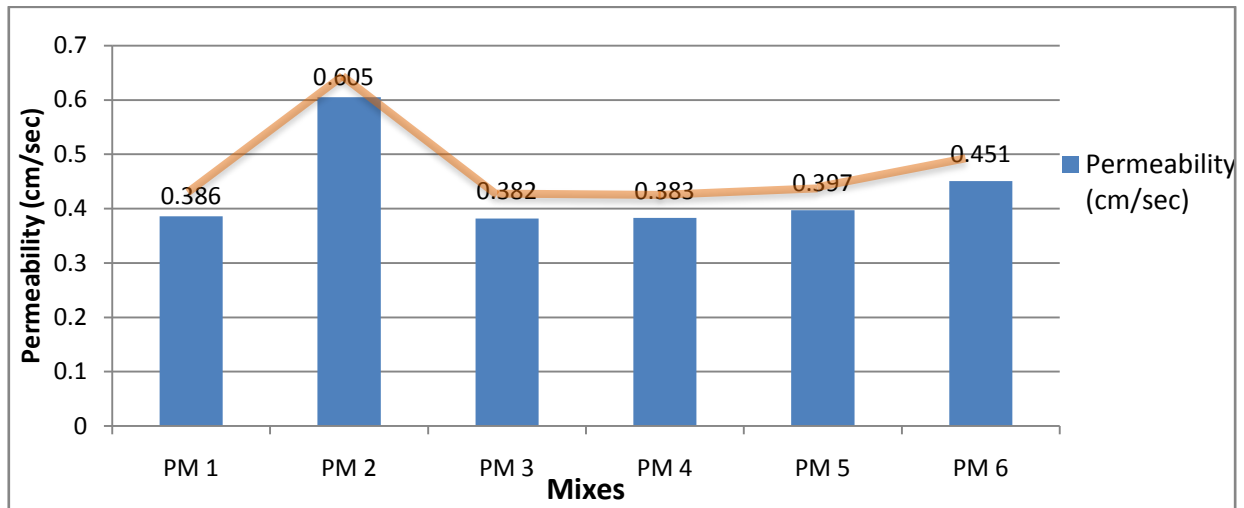


Fig 6 Permeability for Different Mixes

Permeability of pervious concrete mixes showed a major variation for PM 2 mixes. The graph showed that permeability increased with the increase in aggregate size. The addition of supplementary materials showed a marginal difference of 1% - 2%

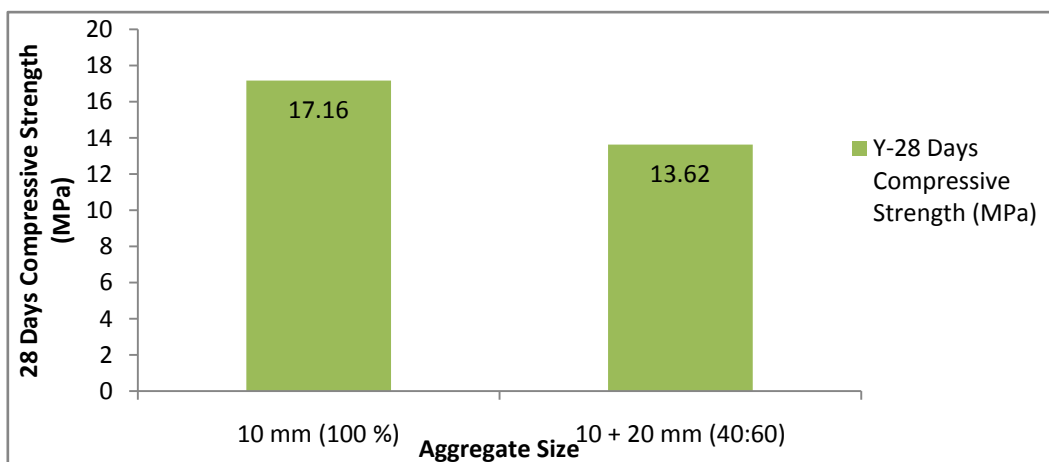


Fig 7 Relation between Aggregate Size and Compressive Strength

Fig 7 is graph which shows about the effect of variation of aggregate size to the compressive strength of concrete. It can be seen that for smaller size aggregate the strength obtained is 26% greater than that for a combination of 10 mm and 20 mm aggregate.

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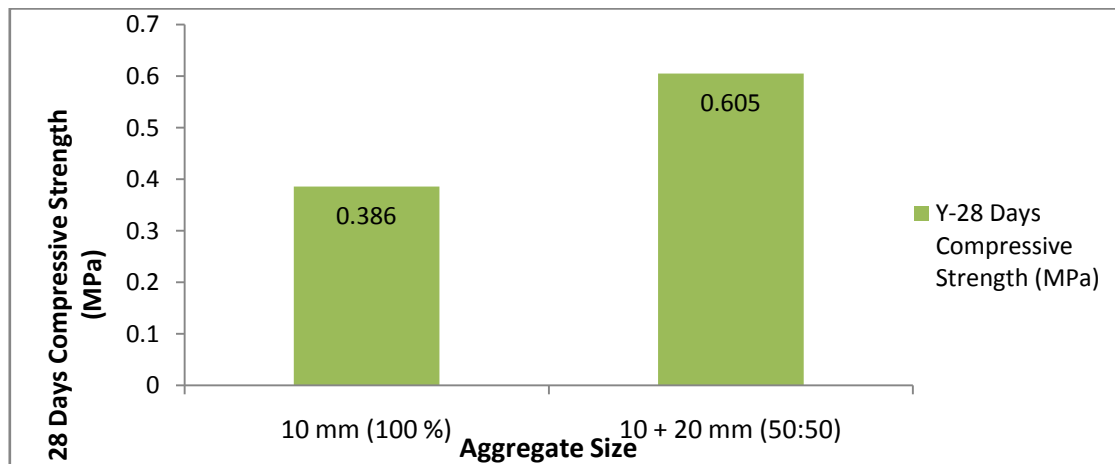


Fig 8 Relation between Aggregate Size and Permeability

For Fig 8 it can be seen that the aggregate size and permeability are related to each other. The lesser the aggregate size lesser is the permeability and vice-versa. The results are reversal for what it is seen for aggregate size and compressive strength.

VIII. CONCLUSIONS

- Grading of aggregate is equally important to get desired strength and on the other hand permeability. Greater the aggregate size the greater is the permeability but lower is the strength and vice-versa.
- A proper gradation of aggregate and mix design is important to get an optimum mix.
- Flyash reduced the strength properties of the concrete, the major reason may be the grade and quality of Flyash.
- GGBS as supplementary material gave a good results regarding the strength properties although lower than 100% OPC.
- Permeability was not much varied due to variation in paste density. Permeability is moreover related to method of compaction and size of aggregates used.
- Pervious concrete can be applied for various engineering applications in India such for Green Building culture, Jogging tracks, low traffic density roads, pavement sidewalks.
- Pervious concrete blocks can also be used in various places which are as good as concrete pavement.

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BIOGRPHY



Husain N Hamdulay holds B.E degree from Saraswati College of Engineering, Kharghar, Navi Mumbai and pursuing his Masters in Civil (Structural Engineering) from University of Mumbai. His research interest includes concrete technology, built environment and structural design.



Mrs. Roshni John holds B.Tech from Kerala University and her M.E (Structural Engineering) from M.G.M College of Engineering, Kalamboli, Navi Mumbai. She is the Head of Civil Engineering Department at Saraswati College of Engineering, Kharghar, Navi Mumbai and has an experience of 13 years teaching analysis and design subject. Her major interests are Structural Dynamic and Design.



Mr. D.R.Suroshe holds M.E (Structural Engineering) Degree form Mumbai University and Bachelor’s degree from Sardar Patel College of Engineering, Mumbai. He is Principal of Revera Institute of Technology, Kharghar having a teaching experience of 10 years. His major interests are Structural Dynamics and Concrete Technology.