



Indian Institute of Technology Ropar

Department of Civil Engineering

Project

Experimental study of Mechanical properties of Cement using Nano Bubble Water

Supervisor:

Dr Muthulingam Subramaniyan

Presented by :

- Archit Shakya (2021ceb1011)
- Deepika (2021ceb1017)
- Himanshu (2021ceb1024)
- Rishikesh (2021ceb1028)
- Tanmay Singh(2021ceb1031)

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INTRODUCTION

The incorporation of Nano Air Bubbles (NAB) into cement and concrete mixtures has gained widespread attention due to its potential to enhance various properties. In this project, (OPC) and (PPC) were utilized alongside Distilled Water (DW) and Nano Air Bubbles (NAB) for comprehensive analysis. Initially, consistency tests were conducted to determine the standard consistency of the mixtures. Subsequently, the initial and final setting times were determined for three samples of each mixture. Following this, **Thermogravimetric Analysis (TGA)**, **Fourier Transform Infrared Spectroscopy (FTIR)**, and **X-ray Diffraction (XRD)** characterization tests were performed to gain insights into the composition and properties of the samples.

Further, 36 cubes were casted, comprising 9 per group for 7, 14 & 28 day testing, each cube measuring 70.6mm in size. These cubes were subjected to compressive strength testing using a Compression Testing Machine (CTM). This comprehensive approach aimed to evaluate the effects of incorporating Nano Air Bubbles on the properties and performance of cement and concrete mixtures.





OBJECTIVES



To study the mechanical properties of cement using distilled water and Nano bubble water :

- To find the consistency of cement sample.
- Determination of initial and final setting time.
- Characterization of the specimens (XRD ,TGA, FT-IR).
- Casting of cubes (9 each of OPC-DW , OPC-NAB, PPC-DW,PPC-NAB).
- Compressive strength of specimens for comparison.

Overview

Properties

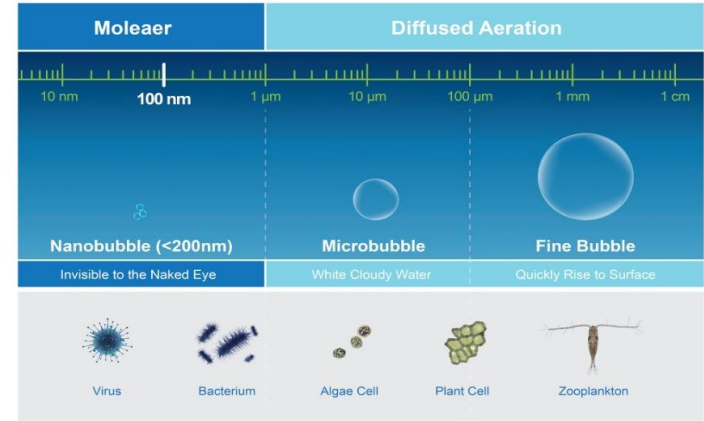
- NBs are one of the smallest known bubble sizes, roughly 2500 times smaller than a single grain of salt, or less than 200 nanometers (nm) in diameter.
- NBs have excellent stability, high internal pressure, and an extremely large surface to volume ratio.
- NBs are neutrally buoyant and can remain suspended in liquid for weeks without rising to the surface and off-gassing.

Tests Performed

- Standard consistency test
- Initial and final settling test
- Compressive strength test

Characterization Test

- **TGA** : Thermogravimetric Analysis
- **FT-IR** : Fourier Transform infrared spectroscopy
- **XRD** : X-ray diffraction



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Need of the Project

- To study unique physical and chemical properties that can influence the behavior of materials they are introduced to

Standard Consistency Test

P(%)	Amount of Water(ml)	Depth of Penetration (mm)
30	120	15
32	128	6.5
32.5	130	2.5

OPC-43 (DW)

P(%)	Amount of Water(ml)	Depth of Penetration(mm)
30	120	12
32	128	12
32.5	130	6
33	132	4.5

OPC-43 (NAB)

P(%)	Amount of Water(ml)	Depth of Penetration (mm)
30	120	16.5
32	128	12
34	136	6.5

PPC (DW)

P(%)	Amount of Water(ml)	Depth of Penetration
32	128	29
34	136	10
35	140	8
36	144	5

PPC(NAB)

- **Standard consistency**
- When the 10mm plunger penetrate the paste to a distance of **5 to 7mm from the bottom** of the Vicat mould.



Initial and Final Setting time Test

The initial setting time of cement is the time between adding water to the cement and when a 1 mm square needle can't penetrate the cement paste by $5 + 0.5$ mm. The final setting time is the time between adding water and when a 5 mm hollow circular needle can't make an impression on the mold

Formulae

Amount of water = 85 % of Standard consistency



Initial and Final Setting time Test

Sample # (OPC+NAB)	Initial Setting Time	Final Setting Time
1	2 hr 21 min	9 hr 12 min
2	2 hr 15 min	9 hr 8 min
3	2 hr 17 min	9 hr 1 min
Average	2 hr 20 min	9 hr 10 min

Sample # (OPC+DW)	Initial Setting Time	Final Setting Time
1	2 hr 49 min	9 hr 41 min
2	2 hr 40 min	9 hr 36 min
3	2 hr 45 min	9 hr 32 min
Average	2 hr 45 min	9 hr 40 min

NOTE: OPC There is decrement of 25 min in initial setting time and 30 min decrement in final setting time
PPC There is increment of 20 min in initial setting time and 30 min decrement in final setting time

Sample # (PPC+NAB)	Initial Setting Time	Final Setting Time
1	2 hr 5 min	9 hr 15 min
2	2 hr	9 hr 10 min
Average	2 hr 5 min	9 hr 15 min

Sample # (PPC+DW)	Initial Setting Time	Final Setting Time
1	1 hr 47 min	9 hr 50 min
2	1 hr 35 min	9 hr 40 min
Average	1 hr 45 min	9 hr 45 min

Characterisation

1. **XRD Test (X-ray Diffraction):**

- Purpose: XRD is a technique used to analyze the crystalline structure of materials. In the context of cement, it helps identify the mineral phases present in the sample.
- Uses:
 - Phase Identification
 - Research and Development

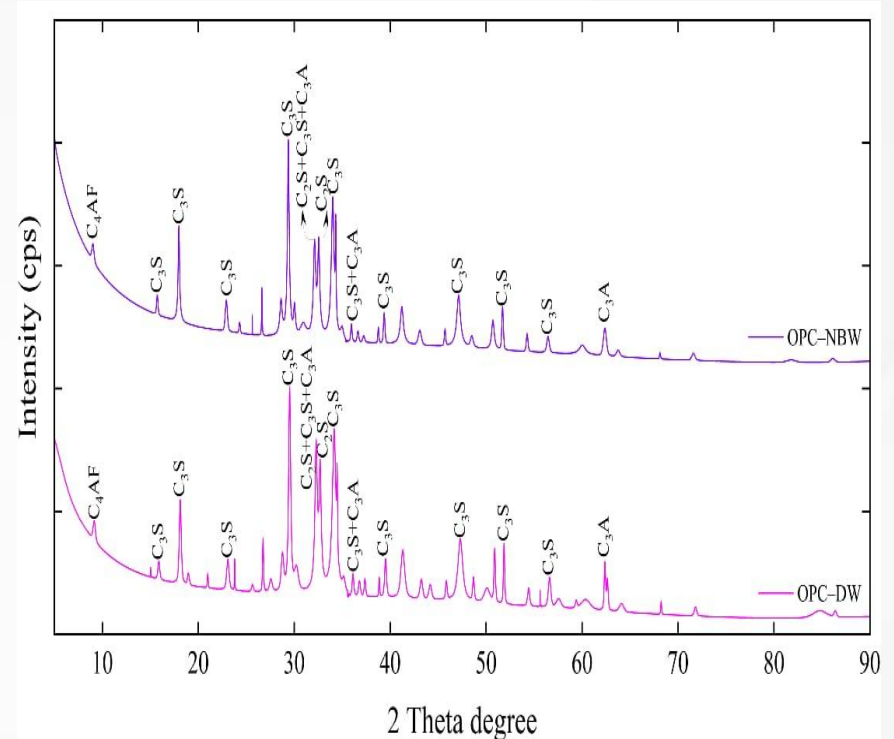
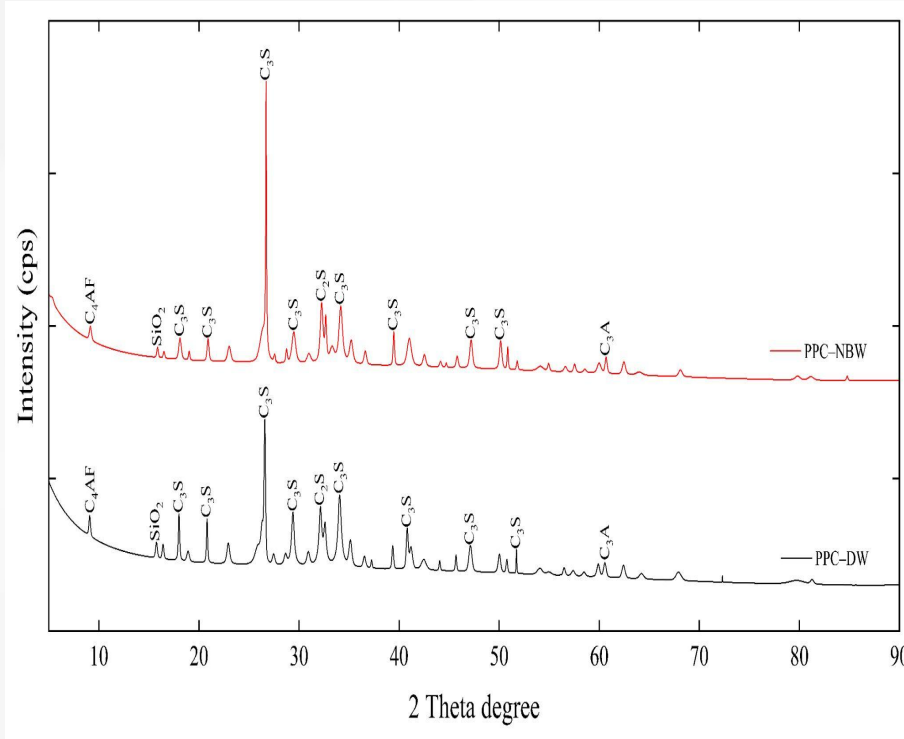
2. **TGA Test (Thermogravimetric Analysis):**

- Purpose: TGA measures changes in mass as a function of temperature, providing information about the thermal properties and decomposition behavior of materials.
- Uses:
 - Hydration Kinetics
 - Composition Analysis

3. **FT-IR (Fourier Transform Infrared Spectroscopy):**

- Purpose: FT-IR measures the absorption of infrared radiation by a material, providing information about its molecular composition and chemical bonds.
- Uses:
 - Additive Detection
 - Hydration Monitoring

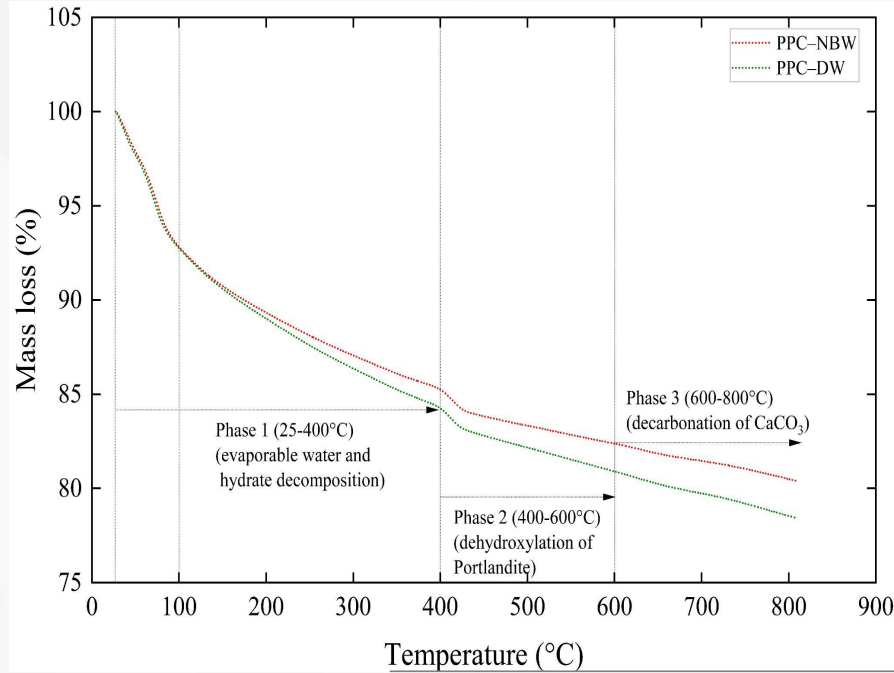
PPC



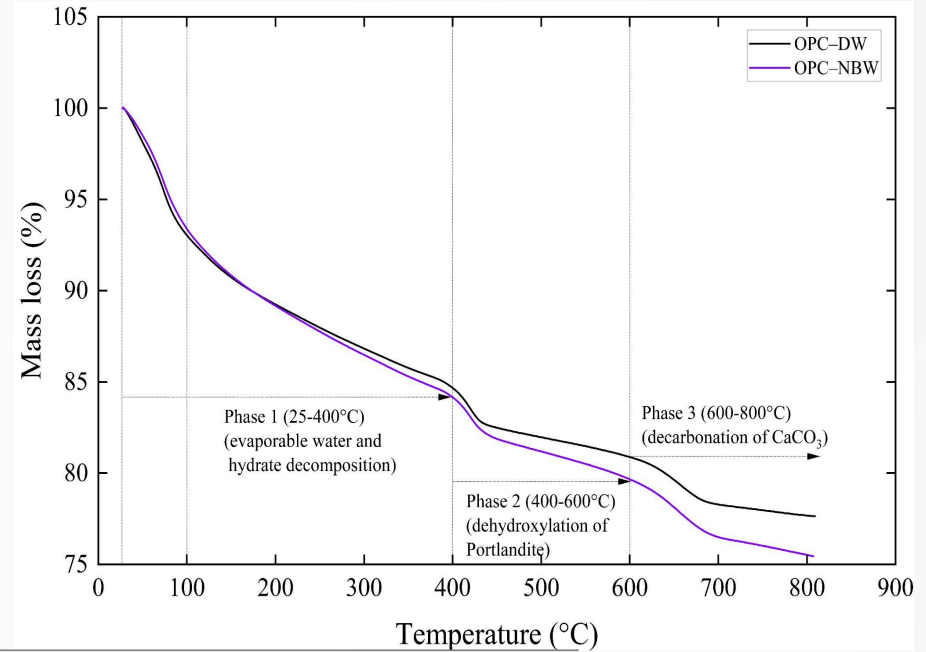
OBSERVATION : We observed that peak occurrence is same in both PPC and OPC i.e. addition of NAB instead of DW does not involve any different reactions within the chemical compositions of PPC and OPC. Presence of various functional groups present in the cement shows reactions (in form of intensity absorbed) at different angle of diffraction.

2.TGA

PPC



OPC

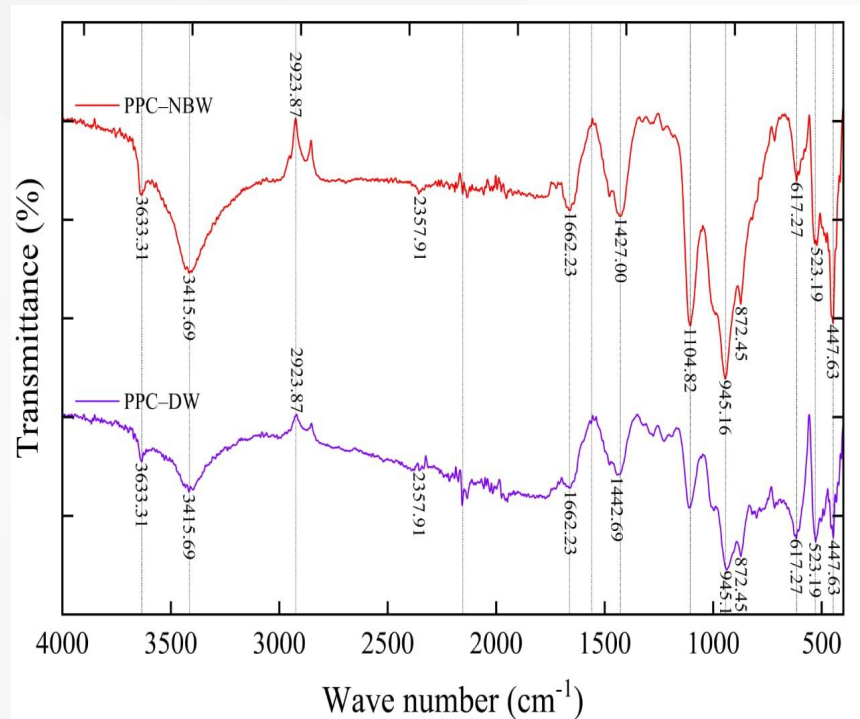


OBSERVATION

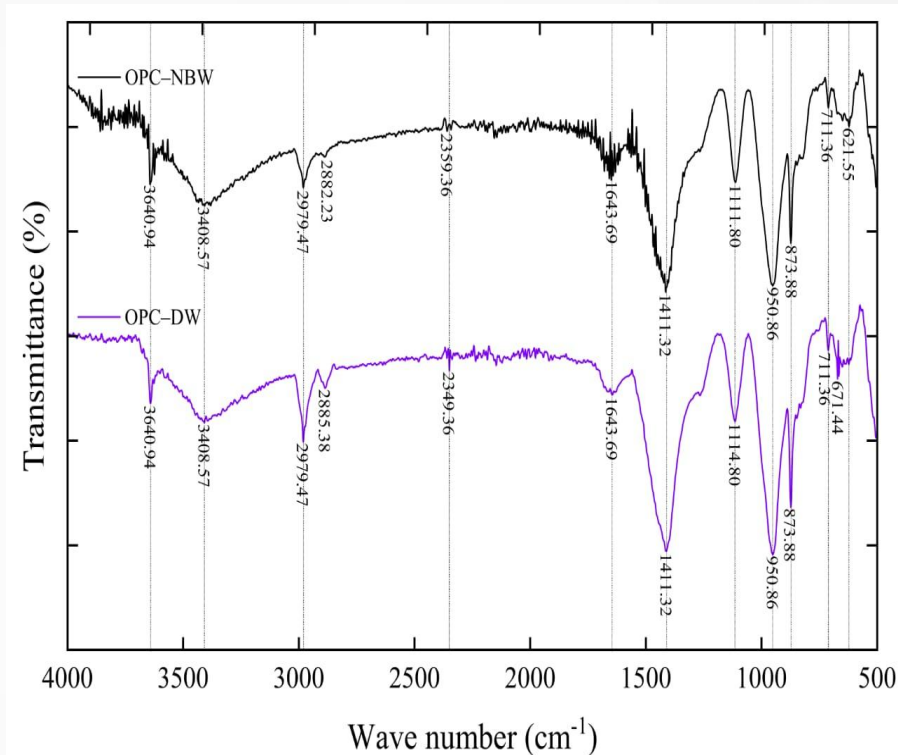
	% mass loss at 105 °C	% mass loss at 400 °C	% mass loss at 600 °C	% mass loss at 800 °C
PPC-DW	7.52	15.78 %	19.10 %	21.52 %
PPC-NBW	7.53 %	14.80 %	17.63 %	19.52 %

3.FT-IR

PPC



OPC



OBSERVATION : From the analysis the chemical composition of cement matrix is not significantly affected by nano bubble water & it confirms the stability of chemical structure of cement with NBW & DW .

Compressive Strength Test

It is a standard procedure used to determine the maximum compressive load a material can withstand before failure, typically in the form of crushing or collapsing

Composition of mixture

1 : 3
Cement (200gm) Sand (600gm)



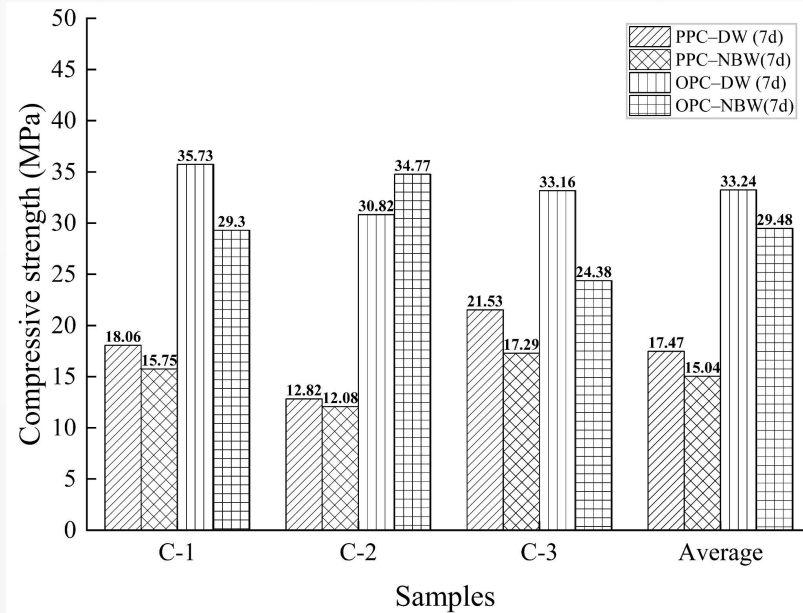
Formulae

Amount of water = $(0.25 P + 3)$ % of Total wt of mixture

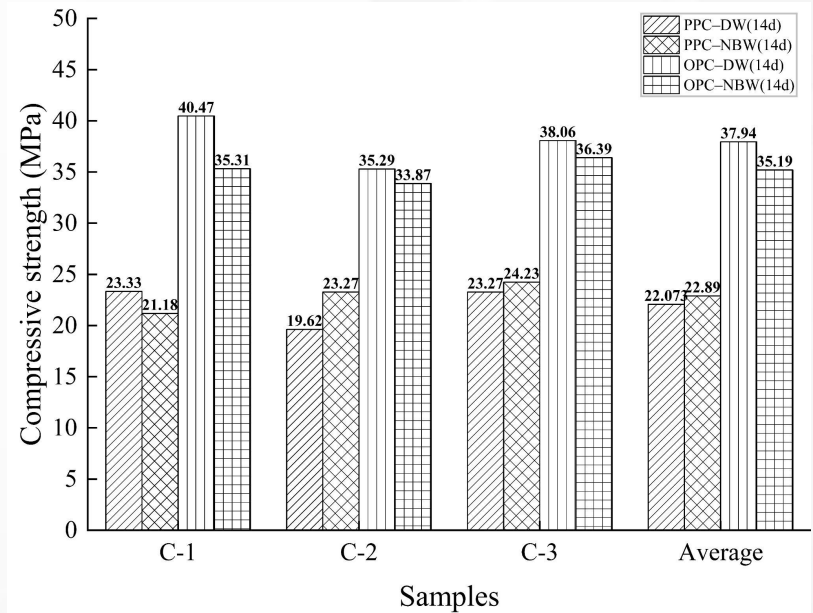
Observation

[Link](#)

7 Days



14 Days



Conclusion

- From XRD and FT-IR analysis, specimen with NAB & DW water we conclude cement is chemically stable.
- The compressive strength test result shows a **decrement of 14.91 %** for the PPC & **11.29 % decrement** at **7 days test** and on **14 days test** for the PPC we got a **increment of 3.72 %** strength compared to distilled water specimen and a **decrement of 7.25 %** in strength for the OPC.
- The main reason for decrement during hydration process is NAB introduction & aeration that creates voids (porosity- void formation phenomenon).
- Finally, using NAB water is a potential attempt for the improvement of mechanical properties of concrete (further testing for 28th day Compressive test results need to done, for more clarified comment on the mentioned properties.
- It may be possible that we find an increase in strength after we conduct the 28th day strength test because we are observing on 7th day OPC with NAB shows 11.29% decrement however on 14th day test results it is showing 7.25% decrement this shows that longer period of testing enhances the strength.

References

- <https://www.innovatechlabs.com/newsroom/672/stuff-works-ftir-analysis>
- H Liu, Z Tian, X Sun, J Xiang, X Jiao, Study on the multiscale properties of cement-based materials containing nano-bubble water, Construction and Building Materials
- M Khoshroo, A Akbar Shirzadi Javid, A Katebi, Effects of micro-nano bubble water and binary mineral admixtures on the mechanical and durability properties of concrete, Construction and Building Materials

Group Member	Contribution
Archit Shakya (2021ceb1011)	Test perform , Cube casting, Research & documentation
Deepika Upadhyaya (2021ceb1017)	Test perform , Cube casting, Research & documentation
Himanshu Kumar (2021ceb1024)	Test perform , Cube casting, Research & documentation
Rishikesh (2021ceb1028)	Test perform , Cube casting, Research & documentation
Tanmay Singh (2021ceb1031)	Test perform , Cube casting, Research & documentation

Thank you