Experimental Investigation of Flexural Strength of Concrete Beam with Cold Joints

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***Abstract*—In reinforced concrete construction, continuous concrete placement is essential to achieve monolithic strength and durability. However, due to delays in concreting operations, interruptions often lead to the formation of cold joints, which act as potential weak planes affecting bond strength, flexural capacity, and long-term performance. This experimental study investigates the flexural strength behavior of M25 grade reinforced concrete beams containing cold joints at different positions and subjected to varying curing methods. Concrete cubes and beams of size 150 mm × 200 mm × 1200 mm were cast and tested. The beams were categorized into five groups: a control beam without a joint and four cold-jointed beams with joints positioned at the mid-span and near supports, under water curing. The flexural tests were performed under two-point loading at 7 days, 14 days, and 28 days as per IS 516:2018, and corresponding compressive strength tests were conducted on cube specimens.**

***Index Terms*—Cold joint, Flexural strength, M25 concrete, Water curing, Reinforced concrete beam.**

I. INTRODUCTION

When concrete hardens, one sort of crack appears called cold joints. These joints only form seams with no discernible void structure rather than creating gaps in the concrete. Typically, a cold joint is linear, tightly connected, and glued. As with every concrete pour, there is the possibility of a tiny void region in the concrete if it is not completely compacted. Future crack growth may result from these tiny voids. If the joint is in compression, cold joint concrete often does not cause any structural issues. However, when evaluating a cold joint, it is important to take into account its position, the element's structural function, and aesthetics. A chilly joint may occasionally be a vulnerable spot. The vertical bar protruding out of the concrete for attachment later is not actually a weak point in terms of structure if concrete has already been put there. At the point where concrete is interrupted, a proper joint is crucial.

This study introduces innovation in the building sector to address the significant flexure failure brought on by joints in beams. the investigation of the use of various geometrical forms and adhesives at the cold joint interface in concrete beams. In the paper, flexural strength of concrete beams with cold joints is experimented with and studied. Because of its many benefits, including its cost- benefit ratio, steady material supply, and high level of durability, concrete is one of the building materials that is employed the most frequently. But because concrete also has a low tensile strength, tensile tension causes rapid cracking. It is typically exceedingly difficult to cast concrete monolithically at the same time because it is also used for infrastructure projects like dams, pavement, and bridges. Typically, concrete is cast gradually over a period of time, forming numerous layers with a cold joint at the boundary between them. The capacity of the mixing plan and the project's parameters determine how much concrete can be worked. Cold joints in concrete have a substantial impact on performance and durability, necessitating additional analysis and research on the strength of concrete as a result of the cold junction. A building project is a short-term, budgeted endeavor that is started to produce a special, limited-edition good, service, or outcome. Produce that one-of-a-kind development on a specific location under circumstances that will never be duplicated, the project team gets together. Construction can start despite numerous uncertainties, but they may be complex and require elevated levels of coordination of permissions, people, products, plant, and materials. As a result, delays are frequent.

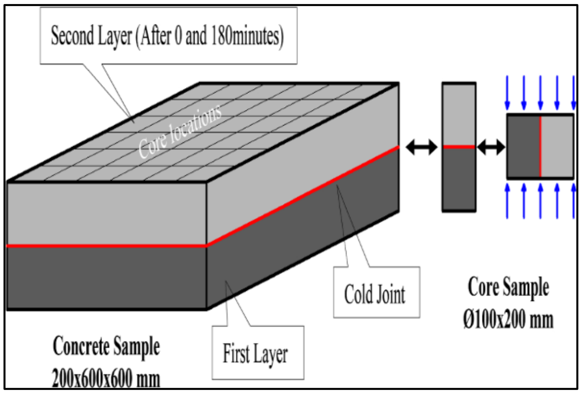


Fig 1 Cold Joints in Concrete

A. Effect of Cold Joint In Structural Elements

- Lack of Bonding: A weak connection between two concrete pours is produced by the creation of a cold joint. It is a result of concrete being poured on top of concrete, which has begun to harden (set). How late we pour the fresh concrete determines how strong the junction will be. We pour the joint weaker afterwards. There can be joint separations if it takes a long time.
- Reduce strength and Durability of Structures: There will be strength difficulties since the newly poured concrete is placed on top of concrete that has already begun to set. Additionally, the wrong joint bonding and tacky setting could affect the concrete's longevity. As a result, concrete durability may be affected by cold joints exposed to the environment.
- Water Leaks: Water leaks through the cold joints are a possibility. Water leaks may occur if a raft foundation has a cold joint that is not waterproofed. If there are cold joints, even a tiny floor slab installed in a bathroom could result in water leaks.
- Deterioration of Concrete: Weak concrete is the result of the cold joint's formation in concrete. It might cause an early decline. The interior regions with cold joints could not be impacted by this. There are several chances that concrete will deteriorate when a joint is exposed to the outside environment.

II. PROBLEM STATEMENT

In large-scale concrete construction, continuous placement of concrete is often disrupted due to equipment limitations, transportation delays, or unforeseen site conditions. These interruptions result in the formation of cold joints, which are weak planes between successive layers of concrete. The presence of cold joints can lead to a reduction in bond strength, shear resistance, and overall flexural capacity of structural elements.

Although several studies have examined the effect of cold joints on compressive and bond strength, there is a lack of systematic experimental data addressing how the position of the cold joint and the type of curing influence the flexural strength of reinforced concrete beams. Understanding these effects is critical for improving construction practices and ensuring structural safety in real-world applications such as bridges, slabs, and retaining walls, where interruptions in concreting are inevitable.

Hence, this research aims to experimentally investigate the flexural strength behavior of M25 grade concrete beams containing cold joints, considering variations in joint position and curing method, and comparing the results with control beams without cold joints.

Table 1 Type of Beam

Specimen ID	Type of Beam	Position of Cold Joint
B1	Control Beam	No cold joint
B2	Cold Jointed Beam	Mid-span (tension zone)
B3	Cold Jointed Beam	Near support (compression zone)
B4	Cold Jointed Beam	one-third span

1) Sample Calculation for Cube Casting:

Cube Size: 150x150x150 mm

= 0.003375 m^3 (wet Volume)

Dry Volume add 54% in wet volume

=1.54 x 0.003375

=0.005198 m^3

Cement = 0.005198 x 394 =2.04 Kg

Sand =0.005198 x 654 =3.39 Kg
Coarse Agg. =0.005198 x 1162 = 6.04 Kg

2) Sample Calculation for Beam Casting:
Beam Size: L x B x H
150 x 200 x 1200 mm
Volume = 0.1 x 0.5 x 0.1
= 0.036 m^3 (wet Volume)

Dry Volume add 54% in wet volume
=1.54 x 0.005
=0.05544 m^3
Cement = 0.05544 x 394 = 21.84 Kg
Sand = 0.05544 x 654 = 36.25 Kg
Coarse agg = 0.05544 x 1162 = 64.42 Kg

III. RESULT AND DISCUSSION

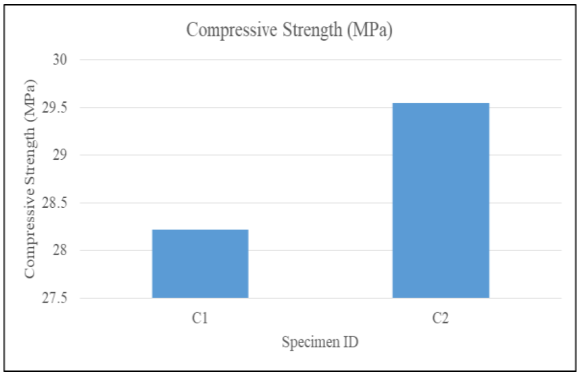
3.1 Compressive Strength Test of Cubes.

Concrete cubes of size 150 mm × 150 mm × 150 mm were cast and cured for 28 days. A total of four specimens were tested to determine the compressive strength of M25 concrete, as per IS 516:2018. The average compressive strength helps verify whether the mix achieved the desired design strength before being used in beam casting.

Table 2 Compressive Strength Results of Concrete Cubes

Specimen ID	Age (Days)	Load at Failure (kN)	Compressive Strength (MPa)
C1	28	635	28.22
C2	28	665	29.55

- Average Compressive Strength: 28.88 MPa



Graph 1 Compressive Strength Results of Concrete Cubes

The test was conducted to determine the actual compressive strength of the concrete mix used for casting the beams. Specimen C1 failed under a load of 635 kN, corresponding to a compressive strength of 28.22 MPa. While specimen C2 failed at 665 kN, giving a strength of 29.55 MPa. The average compressive strength of the two specimens is 28.88 MPa.

3.2 Flexural Strength of Concrete Beams

Table 3 Average Flexural Strength Summary

Condition	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
B1 – No cold joint	3.88	4.64	5.42
B2 – Mid-span	3.46	4.15	4.72
B3 – Near support	3.63	4.39	5.03
B4 – One-third span	3.55	4.26	4.87

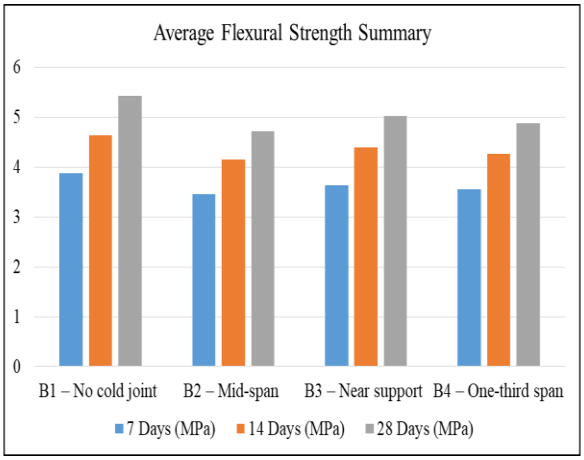


Table 2 Average Flexural Strength Summary

- Strength increased steadily with curing age for all specimens, showing normal hydration and gain in load-carrying capacity.
- The control beam (B1) consistently achieved the highest strength at all ages, indicating superior monolithic behavior.
- Beams with cold joints at mid-span (B2) recorded the lowest strength values at every testing age, confirming that discontinuities in the tension zone critically reduce flexural performance.
- Beams with cold joints near support (B3) and at one-third span (B4) showed slightly better results due to their location in zones of lower tensile stress.

- The 28-day average strength of B2 was about 13% lower than the control beam, while B3 and B4 showed reductions of 7% and 10%, respectively..

IV. CONCLUSION

This experimental investigation was undertaken to study the influence of cold joint position on the flexural strength and quality of reinforced concrete beams of M25 grade. Cold joints occur when fresh concrete is placed over partially set concrete, creating a weak interface that can affect the overall strength and durability of a structural element. The study aimed to quantify this effect by casting and testing four beams (150 × 200 × 1200 mm) with varying joint positions and one control beam without any joint. Tests were performed at 7, 14, and 28 days to evaluate flexural strength development, and Ultrasonic Pulse Velocity (UPV) tests were conducted at 28 days to assess internal concrete quality.

1. The formation of cold joints significantly affects the flexural behavior of reinforced concrete beams, especially when located in the tension zone (mid-span).
2. The control beam (B1) exhibited the highest flexural strength of 5.42 MPa at 28 days, while cold-jointed beams showed reductions of 7–15%, depending on joint position.
3. Beams with cold joints near the support (compression zone) performed better than those with joints in tension regions, indicating that joint location critically influences structural behavior.
4. The average 28-day compressive strength of water-cured concrete cubes was 28.88 MPa, confirming that the designed M25 mix achieved its target strength.
5. UPV test results ranged between 3.45 and 3.85 km/s, classifying the concrete quality as Medium to Good per IS 13311 (Part 1):1992.
6. The control beam (B1) achieved the highest UPV (3.85 km/s), whereas the mid-span joint beam (B2) recorded the lowest (3.45 km/s), confirming the presence of weak bonding and discontinuities at the cold joint interface.
7. Cracking and failure patterns revealed that cold-jointed beams tended to fail along the joint plane, especially when located in tension zones, leading to brittle failure modes. Control beams exhibited typical ductile flexural behavior.

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