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(Research Article)

Comparative experimental study on flexural strength of concrete beams with cold joints using varying hooked rebar configurations

Mansuk Mahadev Idhate *, P. D. Gunaware and Rajendra Subhash Khamkar

Department Of Civil Engineering, HSBPVT's Group of Institutions Faculty of Engineering, Kashti.

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Abstract

This study presents a comparative experimental investigation on the flexural behavior of reinforced concrete beams with cold joints using varying hooked rebar configurations. Cold joints are formed when fresh concrete is placed over previously hardened concrete, resulting in a discontinuity that may influence the structural performance of concrete members, particularly under flexural loading. The primary objective of this research is to examine the effect of cold joint location and the role of hooked reinforcement bars on the flexural response of beams. For this purpose, reinforced concrete beams of M25 grade with dimensions 1200 mm × 200 mm × 150 mm are cast with different cold joint conditions, including mid-span and one-third span locations. Selected specimens are provided with 180° hooked reinforcement bars at the joint interface to study their effectiveness in improving bonding and load transfer. All beam specimens are tested under two-point loading conditions, and their performance is evaluated through parameters such as flexural strength, load–deflection behavior, crack pattern, and failure characteristics at different curing periods. In addition, This study aims to provide a systematic understanding of the behavior of cold jointed beams and the influence of hooked reinforcement configurations, contributing to improved construction practices and structural performance of reinforced concrete elements.

Keywords: Cold Joint; Flexural Strength; Reinforced Concrete Beam; Hooked Reinforcement; Two-Point Loading

1. 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

* Corresponding author: Mansuk Mahadev Idhate

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.

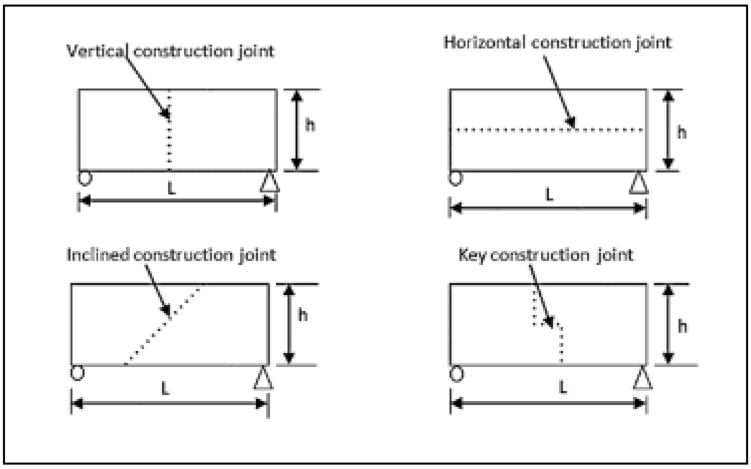

Figure 1 Cold Joints in beam

Cold joints can occur in different orientations vertical, horizontal, keyed, or inclined. A 45° inclined cold joint is selected instead of vertical, horizontal, or keyed joints because it provides a more realistic representation of the cold joints that commonly occur on construction sites due to interrupted concreting, where concrete naturally settles in a sloping pattern rather than forming a perfectly vertical or horizontal plane

2. Material and methods

In reinforced concrete construction, achieving monolithic behavior is critical to ensuring structural integrity and long-term performance. However, due to practical constraints such as equipment breakdowns, labor shortages, or delays in concrete supply, cold joints often form when fresh concrete is placed against already set concrete.

2.1. Problem Statement

The experimental program is designed to study the influence of cold joint position on the flexural strength of concrete beams. All beams are of size 1200 mm X 200 mm X 150 mm and are tested under two-point loading as per IS 516:2018. Main Reinforcement- 10 mm (Top 2 Bottom 2), Stirrups 8 mm - 150mm C/C.

Table 1 Beam Details

Specimen ID	Type of Beam	Position of Cold Joint	Hooked Bar
B1	Control Beam	No cold joint	-
B2	Cold Jointed Beam	Mid-span (tension zone)	-
B3	Cold Jointed Beam	Mid-span (tension zone)	180^{o}
B4	Cold Jointed Beam	one-third span	-
B5	Cold Jointed Beam	one-third span	180^{o}

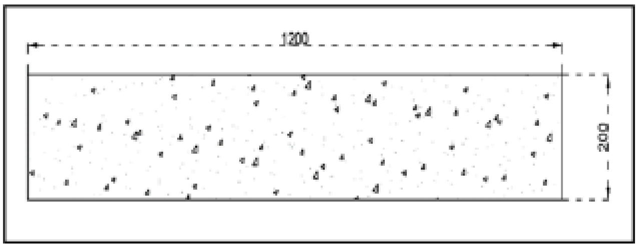

Figure 2 B1 - Control Beam

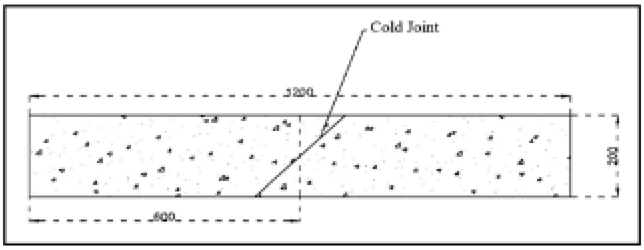

Figure 3 B2 - Cold Joint- Mid-Span

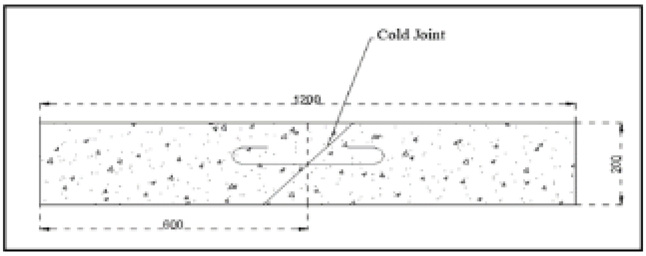

Figure 4 B3 - Cold Joint- Mid-Span- Hooked

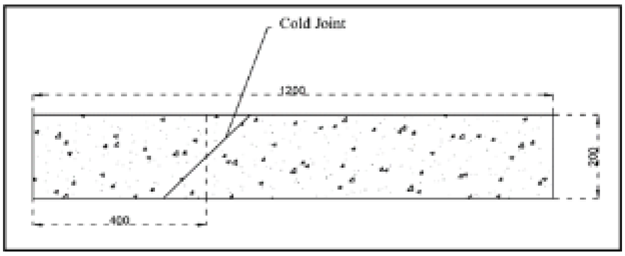

Figure 5 B4 - Cold Joint- One-Third Span

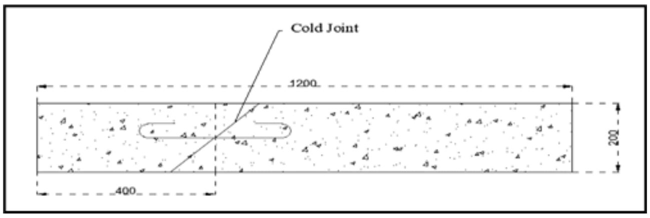

Figure 6 B5 - Cold Joint- One-Third Span – Hooked

3. Results and discussion

3.1. Results for Flexural Strength

Reinforced concrete beams of size 1200 mm X 200 mm X 150 mm were tested under two-point loading as per IS 516:2018. Specimens were divided into two curing conditions and tested at 7 days, 14 days, and 28 days. The flexural strength (modulus of rupture) was calculated using the standard formula.

Table 2 Flexural Strength of Beams - 7 Day

Specimen ID	**Ultimate Load (kN)**			**Flexural Strength (MPa)**			**Average**
	L1	L2	L3	FS1	FS2	FS3	
B1 – No cold joint	41.2	42	40.6	3.88	3.95	3.81	3.88
B2 – Mid-span	36.8	37.4	36	3.47	3.52	3.4	3.46
B3 – Mid-span + Hook	38.4	39	38.2	3.61	3.66	3.58	3.62
B4 – One-third span	37.8	38.4	37.2	3.55	3.6	3.5	3.55
B5 – One-third span + Hook	39.2	39.8	38.6	3.69	3.74	3.63	3.69

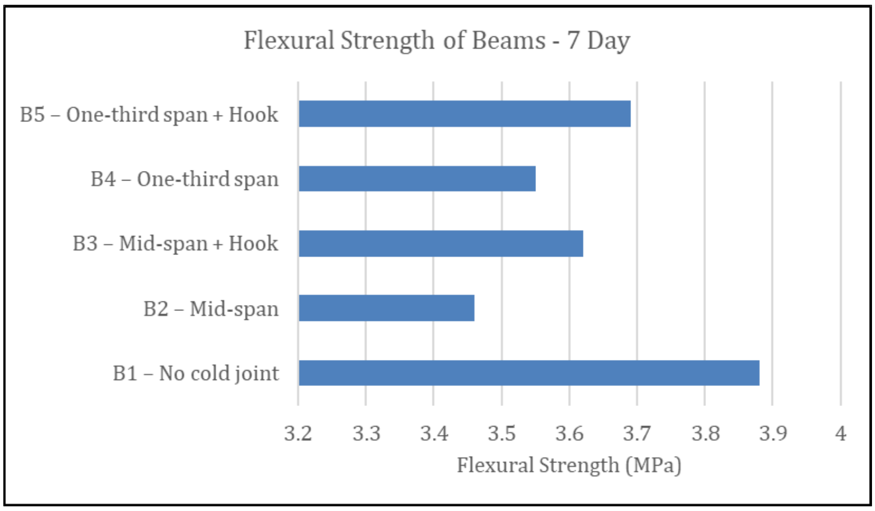

Figure 7 Flexural Strength of Beams - 7 Day

At 7 days of curing, the control beam (B1) achieved the highest flexural strength (3.88 MPa), while beams with cold joints showed reduced strength.

Table 3 Flexural Strength of Beams - 14 Day

Specimen ID	Ultimate Load (kN)			Flexural Strength (MPa)			Average
	L1	L2	L3	FS1	FS2	FS3	
B1 – No cold joint	48.7	49.5	50.2	4.57	4.64	4.71	4.64
B2 – Mid-span	43.2	44	44.8	4.07	4.15	4.23	4.15
B3 – Mid-span + Hook	45.6	46.2	47	4.29	4.35	4.43	4.36
B4 – One-third span	44.6	45.4	46.2	4.19	4.26	4.33	4.26
B5 – One-third span + Hook	46.8	47.3	48	4.4	4.45	4.52	4.46

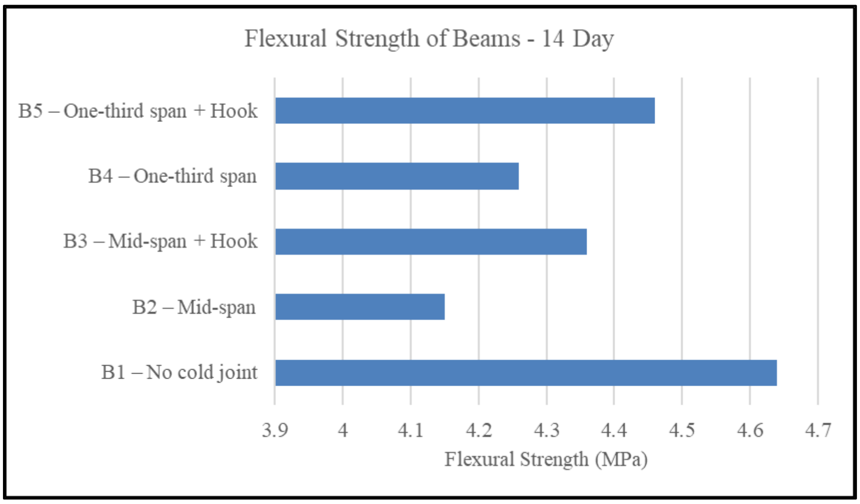

Figure 8 Flexural Strength of Beams – 14 Day

At 14 days, all beams showed increased flexural strength due to continued hydration of concrete. B4 and B5 performed better than the mid-span jointed beams, with B5 showing slightly higher strength due to the hook.

Table 4 Flexural Strength of Beams - 28 Day

Specimen ID	Ultimate Load (kN)			Flexural Strength (MPa)			Average
	L1	L2	L3	FS1	FS2	FS3	
B1 – No cold joint	55.8	56.5	57.2	5.35	5.42	5.49	5.42
B2 – Mid-span	48.6	49.3	50	4.65	4.72	4.79	4.72
B3 – Mid-span + Hook	51.5	52	52.8	4.92	4.98	5.05	4.98
B4 – One-third span	50.5	51.2	51.8	4.81	4.87	4.93	4.87
B5 – One-third span + Hook	52.9	53.6	54.2	5.03	5.09	5.15	5.09

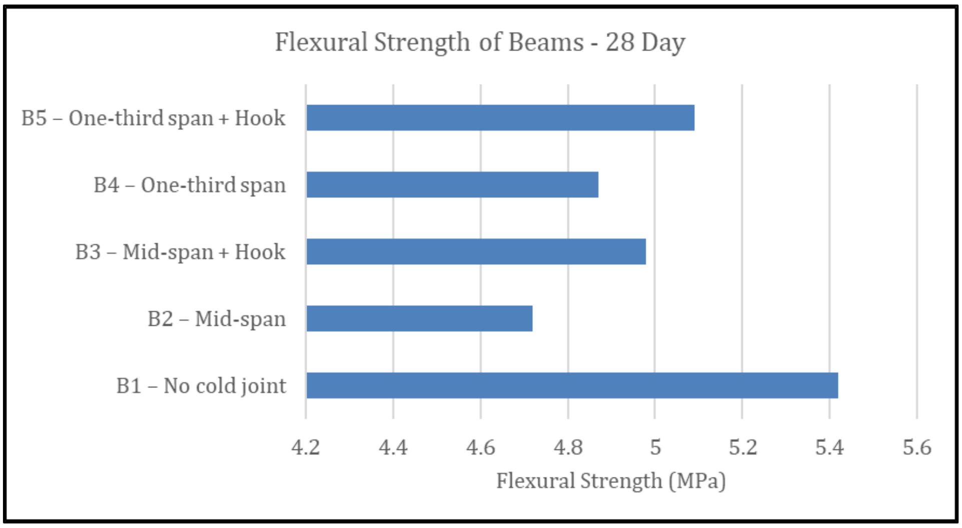

Figure 9 Flexural Strength of Beams – 28 Day

At 28 days, all beams reached their maximum flexural strength B4 performed better than B2 since the joint was at one-third span. B5 showed the best performance among cold joint beams due to the presence of hooked reinforcement.

4. 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 (1200 mm × 200 mm × 150 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.

- The formation of cold joints significantly affects the flexural behavior of reinforced concrete beams, especially when located in the tension zone (mid-span).
- 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.
- 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.
- 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.
- 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.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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IS Codes

- IS 516:1959 — Methods of test for strength of concrete.
- IS 516 (Part 1 / Sec 1):2021 — Hardened concrete methods of test, part 1, section 1: testing of strength of hardened concrete.
- IS 13311 1:1992 — Non-destructive testing of concrete – Methods of test: Ultrasonic Pulse Velocity.
- IS 13311 2:1992 — Non-destructive testing of concrete – Methods of test: Other methods.
- IS 456:2000 — Code of Practice for Plain and Reinforced Concrete. (Referenced often for design and acceptance criteria.)
- IS 1199:1959 — Methods of sampling and analysis of concrete.
- IS 2386 (Part 3):1963 — Methods of test for aggregates for concrete: specific gravity, density, voids, absorption and bulking.