MÜHENDİSLİK ve DOĞA BİLİMLERİ FAKÜLTESİ

Uluslararası Mühendislik Araştırma ve Geliştirme Dergisi
International Journal of Engineering Research and Development

UMAGD, (2024) 16(1), 496-506.

10.29137/umagd.1408221

Cilt/Volume:16 Sayı/Issue:01 Ocak/January 2024

Araştırma Makalesi / Research Article

An Experimental Study on the Behavior of Reinforced Concrete Beams Having Different Angled Cold Joints in the Shear Zone under

Bending Kesme Bölgesinde Farklı Açılarda Soğuk Derzlere Sahip Betonarme Kirişlerin Eğilme Etkisi Altındaki Davranışının İncelenmesi Üzerine Deneysel Bir Çalışma

Süleyman Kamil Akın*[1], Hediye Güz[2]

[1,2] Department of Civil Engineering, Faculty of Engineering and Natural Sciences, KTO Karatay University, 42020 Konya, Turkey

Başvuru/Received: *22/12/2023* ***Kabul / Accepted:*** *22/01/2024* ***Çevrimiçi Basım / Published Online:*** *31/01/2024*

Son Versiyon/Final Version: *31/01/2024*

Abstract

During the construction process of reinforced concrete structures, concrete casting of interconnected structural elements such as columns and beams should be carried out in one piece. However, if concrete pouring cannot be completed due to various reasons, cold joints occur. Cold joint is a manufacturing error that causes poor adherence at the concrete interface as a result of concrete being poured at different times. The main purpose of this study is to investigate the bending behavior and load-carrying capacity of different angle cold joints in the shear zone and beams subjected to four-point loading. In this context, 7 1/2 scale RC beam samples, with dimensions of 150x300x3000 mm, with different cold joint angles, with and without additional reinforcement at the cold joints, were tested. The results were analyzed by comparing parameters such as Load-Displacement curves, Yield Load, Maximum Load, Maximum Displacement, Ductility, Rigidity, and Energy Consumption Capacities. Research has shown that the presence of cold joints, together with changes in their angular orientation, produces remarkable effects on the mechanical performance of reinforced concrete beams. Additionally, increasing the cold joint plane through the addition of steel reinforcement emerges as a factor that may influence the initiation and propagation of cracks within the cold joint zone.

Key Words

"Cold Joint, Reinforced Concrete Beams, Bending Behavior, Shear Zone, Concrete Casting"

Öz

Betonarme yapıların inşaat sürecinde, kolon ve kiriş gibi birbirine bağlı yapı elemanlarının beton dökümü, tek parça halinde gerçekleştirilmelidir. Ancak çeşitli sebeplerden ötürü beton dökümü tamamlanamazsa, soğuk derzler oluşur. Soğuk derz, betonun farklı zamanlarda dökülmesi sonucu beton ara yüzeyinde aderans zayıflığına yol açan bir imalat hatasıdır. Bu çalışmanın temel amacı, kesme bölgesindeki farklı açılı soğuk derzlerin, dört noktadan yükleme tabi tutulan kirişlerin eğilme altındaki davranışını ve yük taşıma kapasitesinin araştırılmasıdır. Bu kapsamda, 150x300x3000 mm boyutlarında, farklı soğuk bağlantı açılarına sahip, soğuk bağlantı noktalarında ilave donatı bulunan ve bulunmayan 7 adet 1/2 ölçekli RC kiriş numunesi test edilmiştir. Yük-Deplasman eğrileri, Akma Yükü, Maksimum Yük, Maksimum Deplasman, Süneklik, Rijitlik ve Enerji Tüketim Kapasiteleri gibi parametreler karşılaştırılarak sonuçlar analiz edilmiştir. Araştırma, soğuk bağlantıların varlığının, açısal yönelimlerindeki değişikliklerle birlikte, betonarme kirişlerin mekanik performansı üzerinde dikkate değer etkiler yarattığını göstermiştir. Ayrıca, çelik takviyenin eklenmesiyle yoluyla soğuk bağlantı düzleminin arttırılması, soğuk bağlantı bölgesi içinde çatlakların başlatılması ve yayılması üzerinde etkili olabilecek bir faktör olarak ortaya çıkmaktadır.

Anahtar Kelimeler

"Soğuk Derz, Betonarme Kiriş, Eğilme Davranışı, Kesme Bölgesi, Beton Dökümü"

***Responsible Author:** *kamil.akin@karatay.edu.tr*

1. Introduction

Cold joint is defined as a manufacturing defect that causes a weakness in the adhesion of the concrete interface. To prevent the formation of cold joints, concrete pouring should be carried out continuously, taking into account the setting time of the concrete. Especially when the dimensions of the concrete elements are large, it is difficult casting of concrete monolithically. It is accompanied by various restrictions on the provision of fresh concrete supply, weather conditions, time, etc. For this reason, concrete casting can't be made monolithically and made in two or more steps. In addition to the improper casting order, the delay of the concrete placement process for many reasons can lead to the formation of cold joints, commonly called "construction joints". This causes changes in mechanical properties such as loss of strength in structural elements that are not suitable for the intended capacity and structural behavior to deal with acting loads. The structural behavior depends significantly on the bonding quality of the concrete-concrete and concrete-reinforcement interface Rao Kishen et al. (2007). In the investigation conducted by Zega et al. (2021), an examination was undertaken to discern the influence of cold joints, along with their directional orientation, on the compressive and flexural strength characteristics of concrete. Cold joints in concrete structures, such as columns and beams, pose significant challenges in construction, particularly in large-scale projects involving mass concrete. These cold joints, resulting from delayed concrete placement, can lead to reduced shear resistance and increased water permeation, impacting the overall structural integrity (Choi et al., 2015). Additionally, the use of intermediate reinforcement is recommended for cast-in-place construction to address potential cold joints between the wall and coupling beam concrete (Parra-Montesinos et al., 2017).

Akın at al(2022) studied flexural behavior of reinforced concrete beams with different cold joint details and found no significant effect from the view of bending capacity.Rao Kishen et al. (2007), tested beams with the cold joint interface between concretes with different mixtures on both sides and were subjected to a bending test from three points to obtain fracture parameters. As a result, they found that the compressive strength of concrete poured later should not be much different from the main concrete. Studies have investigated the effect of the cold joint in concrete on mechanical properties such as shear strength and tensile strength of concrete, and it has been observed that it causes a significant decrease in shear strength and tensile strength due to the presence of the cold joint (Jatheeshan et al., 2010). Turan (2019) worked on the determination of the mechanical properties and fracture behavior of cold-jointed concrete under bending with Acoustic Emission, which was developed as a non-destructive testing method. In this direction, elements with different joint angles, different improvement methods applied to the joint surface, and concrete-to-concrete interfaces with different strengths have been made ready. It has been observed that the ductility and toughness values increase, while the load-carrying capacity decreases since the beams undergoing improvement are in the cold joint drawing zone. It has been concluded that as the difference between the compressive strength of the materials in the beams increases, the load-carrying capacity decreases more. In the study examining the effect of cold joint on the performance of reinforced concrete self-compacting thin concrete beams, test results showed that the effect of cold joint on the ultimate load is more important than the first crack load (Ismael et al., 2019). Rathi and Kolase (2019) investigated the effect of cold joints on concrete strength. In case the concrete casting time is delayed due to various reasons, sugar has been used as an outlet retardant to prevent the cold joint that occurs and tried to solve this problem. As a result, when comparing the concrete prepared by using sugar, which is considered to be an outlet retardant, with normal concrete, they found that sugar does not affect the formation of cold joints very much and prevents them in a very small amount. In their experimental study by Aziz and Ajeel (2010), the shear behavior of reinforced concrete T-beams containing cold joints and the effect of openings or cold joints were examined and they stated that the shear capacity of beams containing cold joints decreased by approximately 27% compared to the reference beam. Illangakoon et al. (2019) experimentally investigated the formation of concrete cold joints in hot weather conditions. The results obtained showed that cold joints were formed in a shorter time than the traditional initial setting time of concrete, especially when the penetration resistance was below 3.5 N/mm². Additionally, it has been determined that cold joints form when the penetration resistance is above 0.5 N/mm² and this resistance is independent of the ambient temperature.

Kadyrov and Yazıcıoğlu (2016) experimentally investigated the effects of cold joints on the bending and direct tensile strength of concrete. Experimental studies were carried out on concrete samples of the C25 class produced. they formed cold joints at 45° and 90° angles in concrete samples prepared in the form of a cylinder with dimensions of 100x200 mm and a prism with dimensions of 100x100x500 mm. The first half of the samples were poured and left for 2, 3, 4, and 6 hours to form cold joints. They carried out bending and direct tensile strength experiments on the prepared samples. According to the results they reached, they determined that there is a decrease in bending and direct tensile strengths in the formation of cold joints as the duration increases.

In the study by Kara and Bekem Kara (2018), in which the effect of cold joint on the adherence strength between concrete and reinforced concrete steel (reinforcement) was examined experimentally with 150x150x150 mm cube samples, they observed that the most loss in all cold joint times was in the adherence strength. They determined the highest strength losses in 180 minutes of cold joint formation. Compared to the reference sample, concrete compressive strength is 2.25%, splitting tensile strength is 7.86%, and bending strength is 14.66%; They observed that there was a 17.17% decrease in the bond strength between reinforcement and concrete. Unlu (2018) experimentally examined the effect of cold joints on the compressive and flexural strength of concrete in his study. it formed half-filled, cold joints at 45 and 90 angles to concrete samples prepared in the form of a cylinder measuring 150×300 mm, a cube measuring 150×150×150 mm, and a prism measuring 100×100×500 mm. According to the results he reached, he found that cold-jointed concrete prepared by filling half has higher bending strength than concrete prepared at 45 and 90 angles, fractures occurred in all cold-jointed samples formed at 90 angles in bending strength experiments were at cold joints, cold-jointed concrete formed at 45 angles in bending strength experiments gave a higher strength value than cold-jointed concrete formed at 90 angles. Udoh (2020) conducted tests to investigate the effects of cold joint formation on concrete compressive strength. Three different types of cold joints (in horizontal, vertical, and diagonal planes) were created in cylinder specimens, and it was demonstrated that specimens with cold joints created in horizontal and vertical planes had the highest and lowest concrete compressive strength, respectively. Koh et al. (2019) examined the service life evaluation of RC T-beam under carbonation by taking into account the effects of cold joints and loading. In the study, after applying tensile and compressive stresses, they performed an accelerated carbonation test for normal-strength concrete and slag. Since the service life is significantly reduced due to the increased carbonation depth for the cold joint in the tensile section, it is concluded that special attention should be paid to cold joints during maintenance, they noted.

Roy and Laskar (2017) conducted tests to investigate the seismic behavior of exterior column-beam joint specimens with cold joints (by casting the upper column later). A significant decrease in the energy absorption capacity and ductility values of the specimens with cold joints was observed. It was also found that the first crack occurred on the cold joint plane. In the study conducted by Aymak (2020), the effect of cold joints formed at the lower and upper ends of columns during the manufacture of reinforced concrete structures on the strength and ductility of the structure with the effect of axial load on the columns was experimentally investigated. As a result of experiments considering the cyclic loading under the influence of axial load for the structure with a cold joint and one without a cold joint, it has been seen that axial load and cold joint affect the behavior of a column-beam connection area. Vanlalruata and Marthong (2021) made tests for 0,7 m long reinforced concrete beams under bending, the values of bending (flexural) strength, ductility, and energy absorption capacity decreased for beams with cold joints (45° angle to the horizontal) due to due to longer casting times for the sections with cold joints. It has been stated that the location and slope of the cold joint in the beams have a significant effect on the beam strength and the best joint location is at the minimum shear point (Abass, 2012).

According to the literature search, it is seen that many studies were presented by the researchers to investigate a better understanding of the impact of cold joints and the effect of shear reinforcement addition in cold joint zones on the load-carrying capacity and ductility of reinforced concrete beams under bending. Within the scope of this study, the structural bending behavior of beam samples having cold joints with different joint angles and with and without additional reinforcements at cold joints interface was tested by four-point bending loading. Furthermore, the failure modes of beams were determined and compared the performance of the reference beams to the beams with cold joints. The findings from this study can be used to improve construction practices and design guidelines for reinforced concrete structures.

Obtained results showed that cold joints at shear zone with regular stirrup spacing has limited effect on bending capacity.

2. Materials and Method

2.1. Material Properties

The specimens used in the experimental studies conducted within the scope of this study were constructed using C25/30 concrete and B420C reinforcement. The mechanical properties of the material obtained from laboratory tests are given in **Table 1**. Concrete and steel properties are obtained according to TS EN 12390-2 and TS 708.

Table 1. Properties of the materials

Properties of concrete utilized					
Concrete grade	Concrete age (Days)	f_{ck} (MPa)	f_{cd} (MPa)	f_{ctk} (MPa)	f_{ctd} (MPa)
C20/25	7	20,28	13,52	1,57	1,05
C20/25	28	25,69	17,12	1,77	1,18

Properties of reinforcement utilized			
Reinforcement diameter	**f_{yk} (MPa)**	**f_{su} (MPa)**	**f_{yd} (MPa)**
Ø6	497,0	533,7	432,2
Ø10	476,0	593,3	413,9
Ø12	466,0	585,0	405,2

2.2. Reinforcement Details and Test Setup

The reinforcement ratio of double reinforced concrete beams was calculated from the equation ρ-ρ'< $0.85\rho_b$. ρ, ρ' and ρ_b represent the ratio of tension , compression and balanced reinforcement, respectively. Since the reinforcement ratio of all reinforced concrete beams is less than ρ-ρ'=0.00166 < 0.85ρb, they are sub-equilibrium beams, and the yielding starts from the tension reinforcement first Ersoy and Özcebe (2016). Where ρ is tensile reinforcement ratio, ρ' compression reinforcement ratio, and ρb is reinforcement of equilibrium. All test specimens have the same reinforcement details. There are two steel reinforcements with a diameter of 12 and 10 mm, respectively, in the tension and compression zones (**Figure 1**).

The reinforced concrete beam experiments were conducted at the KTO Karatay University. To investigate the bending strength and behavior of the specimens, monotonic loading (4-point loading) was applied and measured with a load cell having 300 kN capacity. The displacement of the reinforced concrete beam specimens was measured by linear displacement transducers (LVDT) at the midpoint of the beam and under loads. In addition, an LVDT with a string was fixed at the shear zone of each of the beam specimens. The experimental setup of the reinforced concrete beam specimens is given in **Figure 2**.

While calculating the bending moment capacities of the beams, three basic assumptions were taken into account in addition to the material models. The first is that the plane sections before bending remain plane after bending, the second is that the contribution of the concrete in the tension zone is neglected, and the third is that full adherence is assumed between the reinforcement and the concrete. The theoretical bearing capacity of all test elements was calculated as 66.14 kN.

2.3. Reinforced Concrete Beam Experimental Elements

The study aims to investigate the effect of different angle cold joints on the structural behavior of beams under bending. A total of seven reinforced concrete beams have been produced for this purpose, and one of the seven samples is a reference sample. The remaining 6 reinforced concrete beam samples are designed with cold joints at different angles (0°, 45°, and 90°) in the shear zone. The cold joint interface of the CJ45R and CJ90R beam samples is reinforced by using three 150 mm long 12 mm diameter reinforcements. CJOR reinforced concrete beam sample is reinforced by using nine 150 mm long 12 mm diameter reinforcements with an interspace of 300 mm to the cold joint plane. All beams have the same concrete strength, longitudinal, and transverse reinforcement details (Figure 1). Figure 3 shows the cold joint plane formed in the shear zone after the first concrete casting.

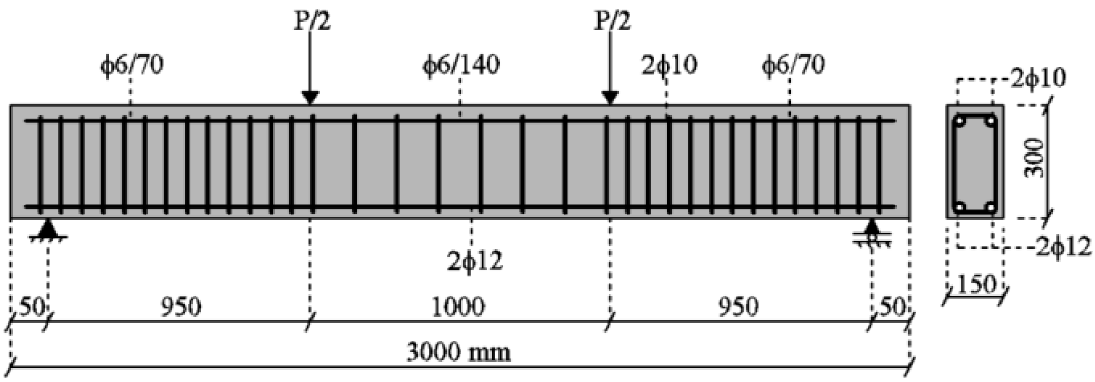


Figure 1. Simply supported reference reinforced concrete beam cross-section dimensions and reinforcement layout (REF)

Figure 2. Experimental setup

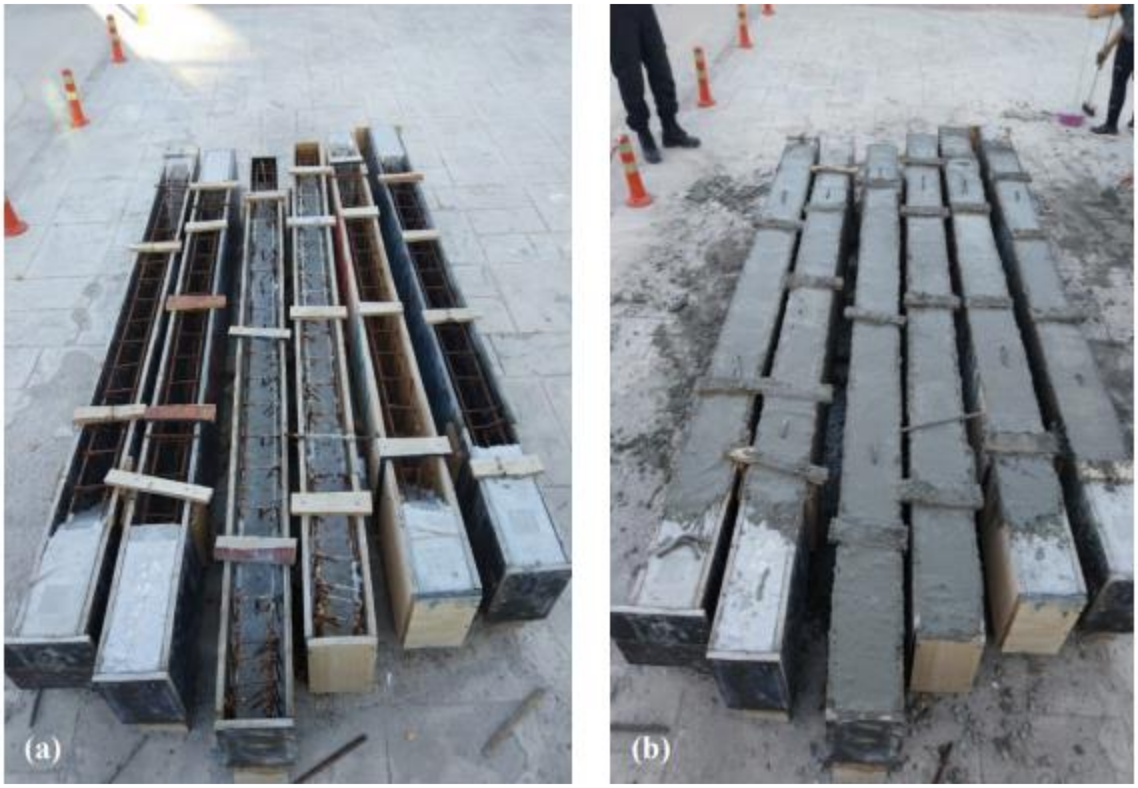
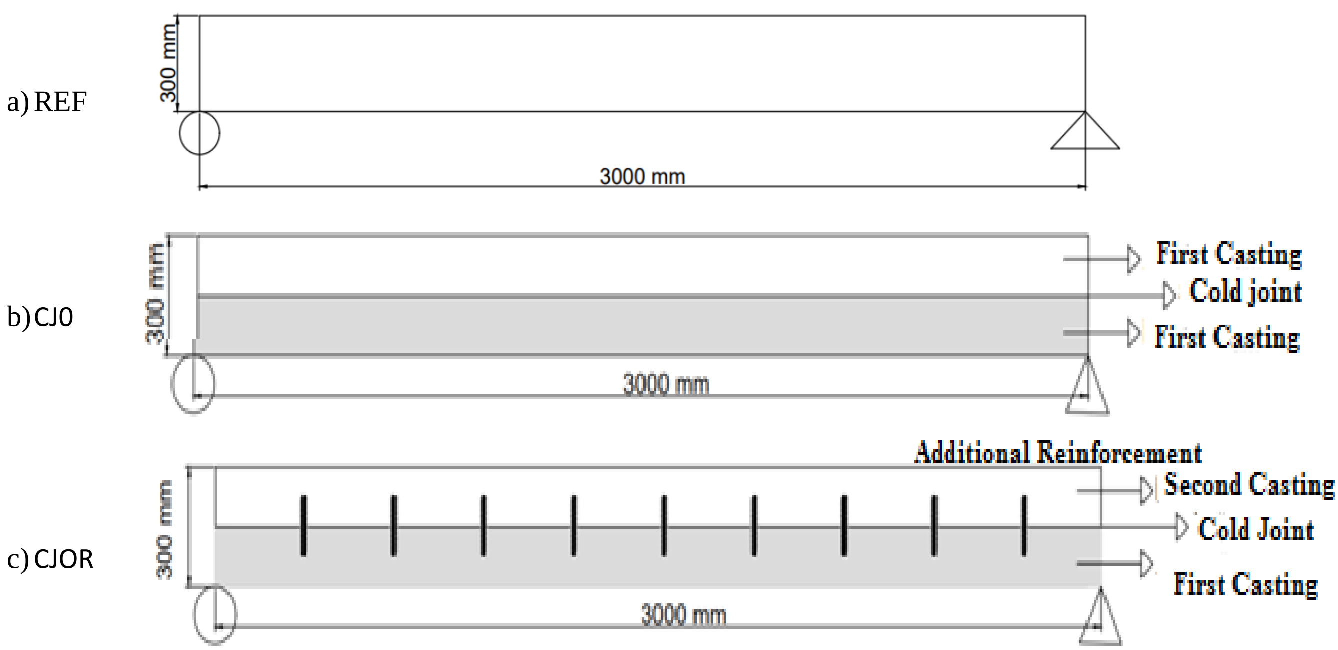


Figure 3. Cold Joint formation

In Figure 4, details of the produced seven beams for experiments according to this casting are given.



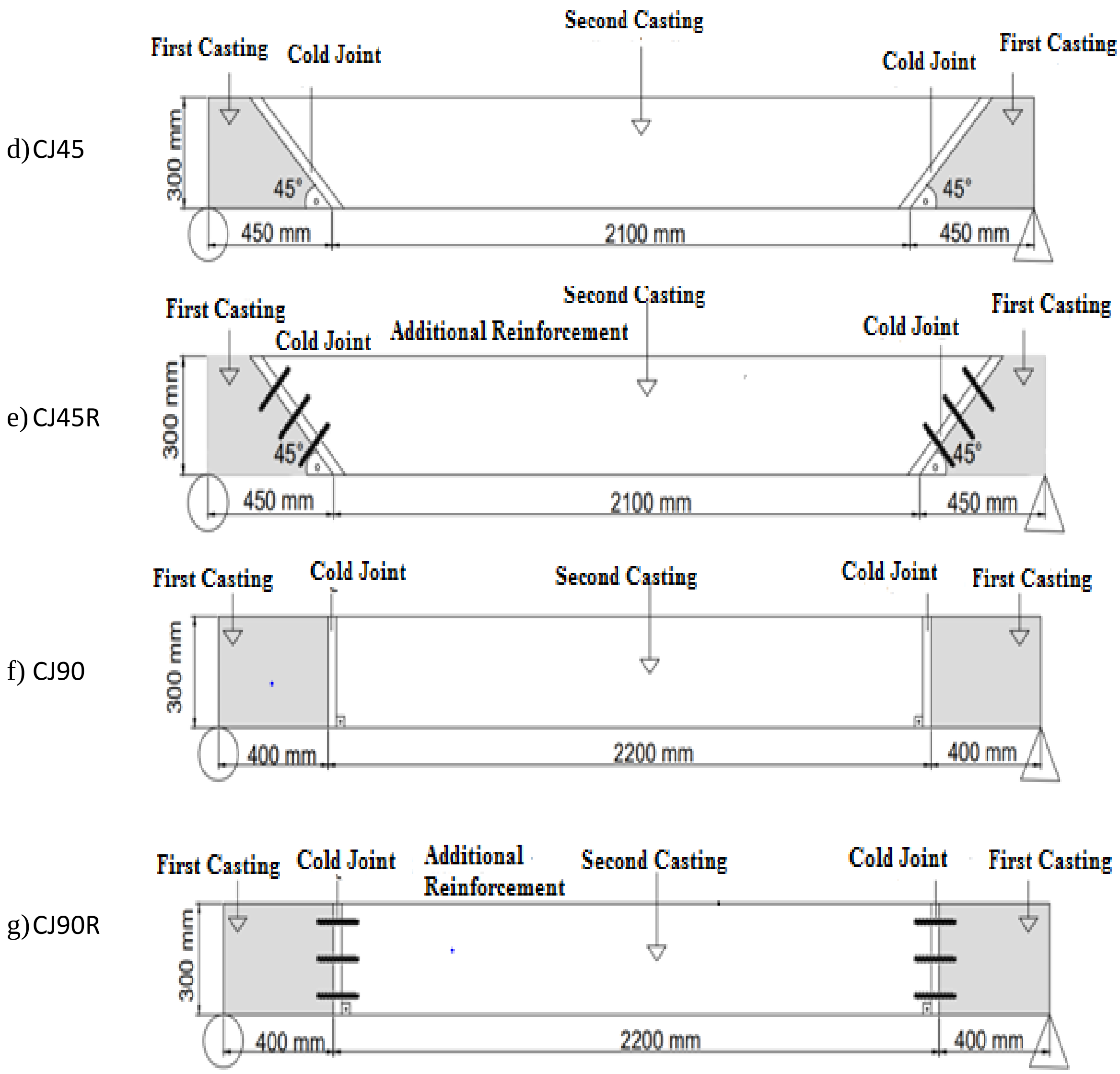


Figure 4. Types of produced beams for experiments

In Figure 4, details of the produced seven beams for experiments according to this casting are given in Figure 3 which shows the cold joint plane formed in the shear zone after the first concrete casting. The abbreviations for the beams given in Figure 4 are; reference beam sample as REF, reinforced concrete beam sample with 0° angle cold joint as CJ0, reinforced concrete beam sample with 0° angle cold joint additional reinforcement as CJOR, reinforced concrete beam sample with 45° angle cold joint as CJ45, reinforced concrete beam sample with 45° angle cold joint additional reinforcement as CJ45R, reinforced concrete beam sample with 90° angle cold as CJ90 joint, and reinforced concrete beam sample with 90° angle cold joint additional reinforcement as CJ90R. In **Table 2**, details of the experimental samples are demonstrated. Additional reinforcements having 12 mm diameter have 300 mm spacing for CJOR, 100 mm spacing for CJ45R, and 7 cm for CJ90R

Table 2. Details of the experimental samples

Beam experimental elements	**Types of cold joint planes**	**Additional reinforcement in cold joint planes**
Reference (REF)	-	-
CJ0	Extending to half the height of the beam	-
CJ0R	Extending to half the height of the beam	Existent
CJ45	Making a 45-degree angle with the horizontal - in the beam shear zone	-
CJ45R	Making a 45-degree angle with the horizontal - in the beam shear zone	Existent
CJ90	Making a 90-degree angle with the horizontal - in the beam shear zone	-
CJ90R	Making a 90-degree angle with the horizontal - in the beam shear zone	Existent

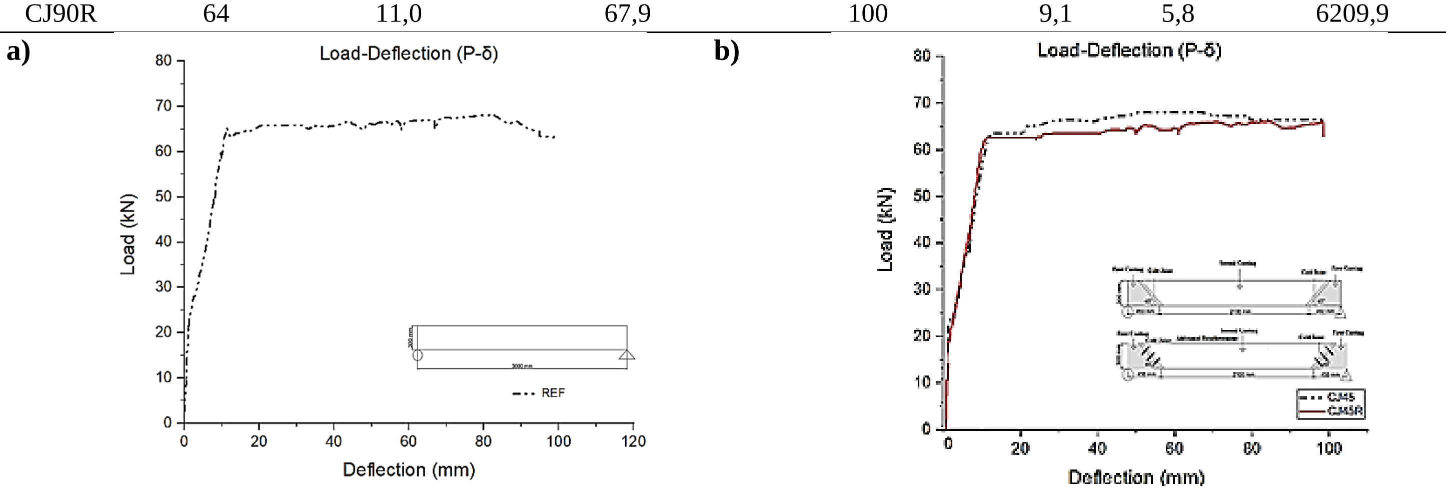
3. Results and Discussion

Reinforcing steel reinforcements were not used at the cold joint interface in CJ0, CJ45, and CJ90 beams. In CJ0R, CJ45R, and CJ90R beams, reinforcing steel reinforcement was used at the cold joint interface. In CJ45R and CJ90R beams, the cold joint plane was reinforced with three 150 mm long and 12 mm diameter reinforcements perpendicular to the cold joint plane. The cold joint plane in CJ0R beam was reinforced with nine 150 mm long 12 mm diameter steel reinforcements spaced 300 mm apart. The load-deflection curves for these specimens are presented **in Figure 5**. All test specimens exhibited ductile behavior and reached their load-carrying capacity.

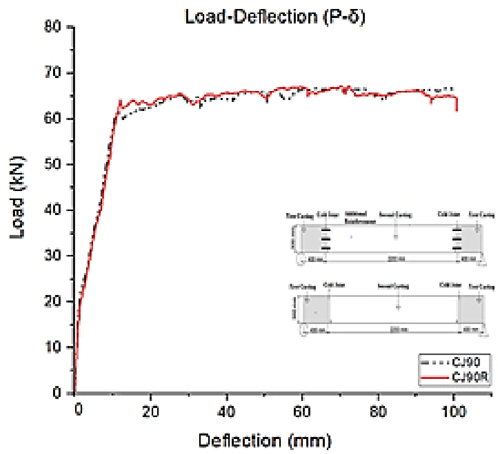
Figure 5 illustrates that the inclusion of additional reinforcement at the cold joint does not yield a discernible positive impact on the load-deflection values. However, it is noteworthy that the angular orientation of the cold joint significantly influences the load-bearing behaviors, particularly observed in samples CJ45 and CJ45R, emphasizing the substantive impact of cold joint angles on structural performance. Provided yield load, yield displacement, maximum bearing load, maximum displacement, ductility and stiffness ratios, and energy dissipation capacity of reinforced concrete beams are given in **Figure 6** and **Table 3.** Upon examination of the findings presented in Table 3, and Figure 6, it is observed that the yield displacements diminish in beams incorporating cold joints. Conversely, the reduction in maximum bearing load and energy dissipation capacities is marginal. Notably, a significant decline in stiffness is evident, particularly in samples with cold joints at 45 and 90-degree angles. This phenomenon is primarily explained as cold joints preventing the monolithic behavior of concrete matrix. Moreover, an increase in the cold joint angle correlates with a concurrent reduction in stiffness.

Table 3. Yield load, yield displacement, maximum bearing load, maximum displacement, ductility and stiffness ratios, and energy dissipation capacity of reinforced concrete beams

Name of Specimen	Yield Load (kN)	Yield Displacement (mm)	Maximum Bearing Load (kN)	Maximum Displacement (mm)	Ductility (δu/δy)	Stiffness	Energy Dissipation Capacity (kN.mm)
REF	65	11,0	69,0	100	9,1	6,5	6304,8
CJ0	63	10,3	69,6	100	9,7	6,3	6378,9
CJ0R	63	10,2	70,1	100	9,8	6,2	6440,6
CJ45	62	10,8	69,1	100	9,3	5,7	6333,1
CJ45R	63	9,7	66,9	100	10,3	6,5	6153,2
CJ90	62	10,5	67,6	100	9,6	5,9	6208,6
CJ90R	64	11,0	67,9	100	9,1	5,8	6209,9



c)



d)

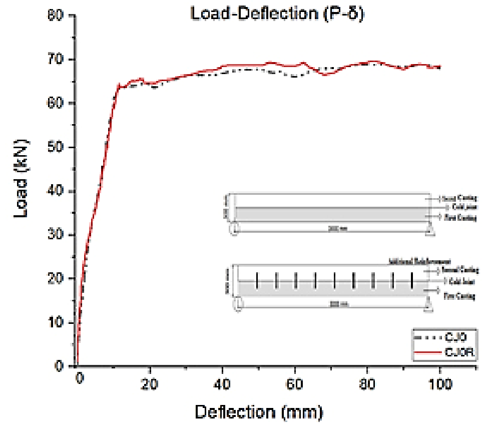
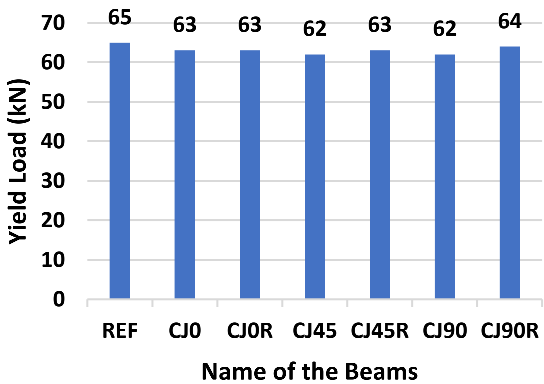
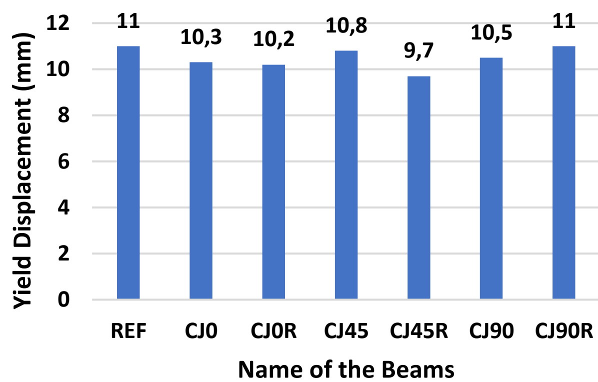


Figure 3. (a) Reinforced concrete reference beam sample REF, Comparative load-displacement curves of reinforced concrete beam members (b) CJ45-CJ45R, (c) CJ90-CJ90R, (d) CJ0-CJ0R

(a)



(b)



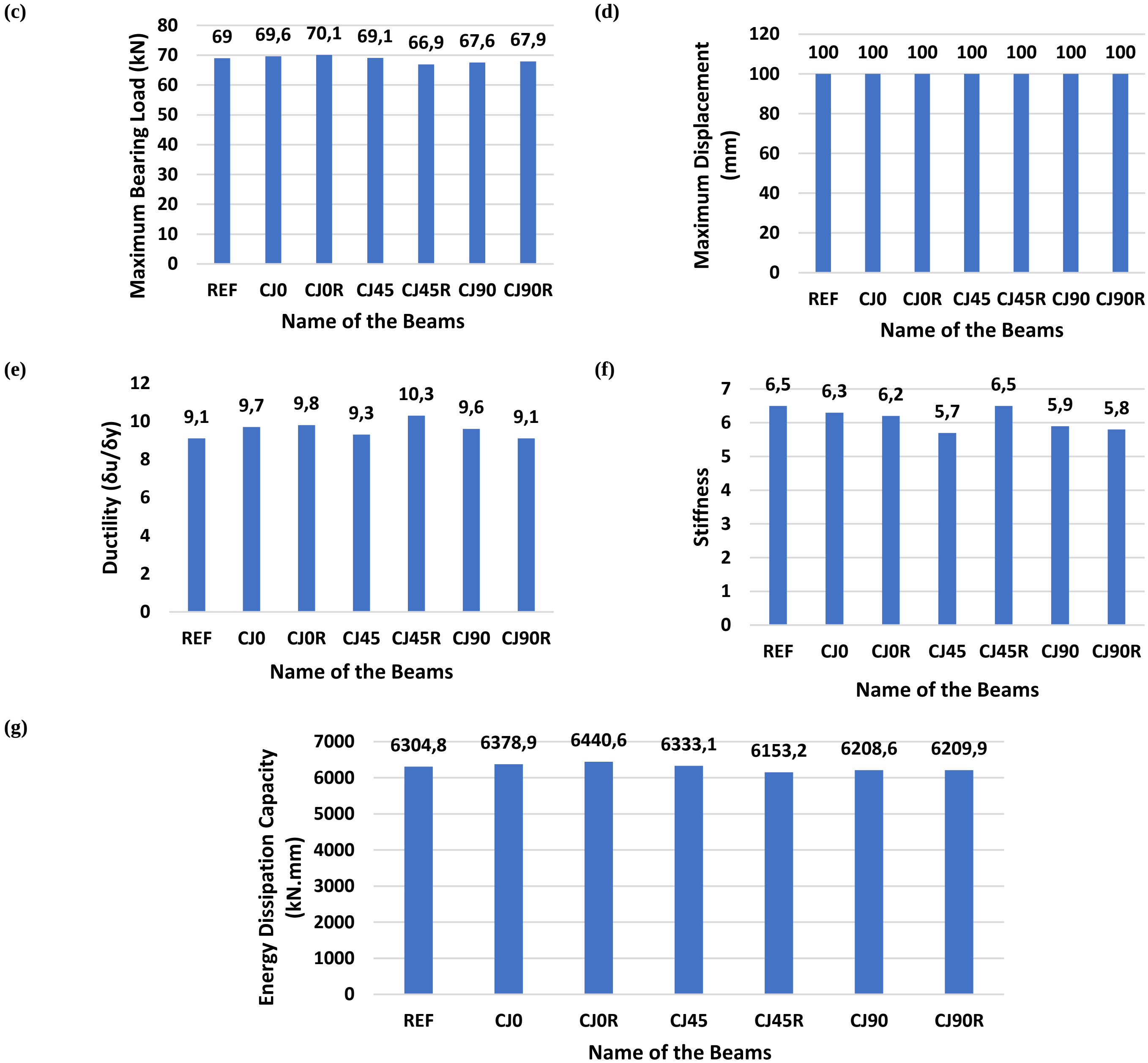


Figure 4. Comparative graphs of (a) yield load, (b) yield displacement, (c) maximum bearing load, (d) maximum displacement, (e) ductility, (f) stiffness ratios, and (g) energy dissipation capacity of reinforced concrete beams

4. Conclusion

In the context of this research, the structural bending behavior of beam specimens featuring cold joints, varying joint angles, and with or without supplementary reinforcements at the cold joint interface has been examined through four-point bending loading. Additionally, the study identifies the failure modes of the beams and compares the performance of reference beams to those incorporating cold joints. The insights gained from this investigation hold the potential for enhancing construction practices and refining design guidelines for reinforced concrete structures.

In conclusion, this experimental study, which encompassed one reference beam and six reinforced concrete beams with cold joints at different angles (0º, 45º, and 90º), subjected to four-point loading tests, has provided valuable insights into the behavior of such structures under bending. The key findings are summarized as follows:

- Effect of Stirrup Spacing:

As stirrup spacing increases, the beams exhibit a decrease in yield load, an increase in yield displacement, a decrease in maximum load, consistent maximum displacement, a decrease in ductility ratio, a decrease in stiffness ratio, and a decrease in energy dissipation capacity.

- Comparison with Unreinforced Beams (Zero-Degree Cold Joints):

Yield load remains constant, while yield displacement decreases. Maximum load increases, and maximum displacement remains constant. The ductility ratio increases, the stiffness ratio decreases, and energy dissipation capacity increases, except for CJ0R, which may have a 2% increase.

- Comparison with Unreinforced Beams (Forty-Five Degree Cold Joints):

Yield load increases, yield displacement decreases, maximum load decreases, maximum displacement remains constant, the ductility ratio increases, the stiffness ratio increases, and energy dissipation capacity decreases.

- Comparison with Unreinforced Beams (Ninety-Degree Cold Joints):

Yield load increases, yield displacement increases, maximum load increases, maximum displacement remains constant, the ductility ratio decreases, the stiffness ratio decreases, and energy dissipation capacity increases.

- Crack Analysis of Cold Joint Regions:

CJ0R exhibits cracks in the shear and bending zones exceeding the cold joint plane; reinforcing with steel does not affect crack formation. CJ45R features an oblique crack influenced by reinforcing the cold joint plane with steel. CJ90R shows no cracks at the cold joint, likely due to reinforcement with steel.

In summary, the study underscores the pronounced influence of cold joints and their varying angles on the mechanical behavior of reinforced concrete beams. Furthermore, reinforcing the cold joint plane with steel has been shown to impact crack formation within the cold joint region. These findings contribute to a deeper understanding of the structural response to bending in reinforced concrete beams with different angled cold joints.

In further studies, the effect of the angle of cold joint effect and additional reinforcement should be studied with beams having higher bearing capacity. This will give researchers a comprehensive understanding and contribution of the nuanced influence exerted by cold joints in structural elements.

5. References

Abass, Z.W. 2012. “Effect of construction joints on performance of reinforced concrete beams” Al-Khwarizmi Engineering Journal, 8(1), 48-64.

Akın SK, Kartal S. Müsevitoğlu A, Zia AJ, Sancıoğlu S. 2022 “Flexural Behavior of Reinforced Concrete Beams with Different Cold Joint Details” UMAGD, (2022) 14(2), 447-456

Aymak, İ. 2020. “Investigation of the effect of cold joints on the strength and ductility of the joints in reinforced concrete buildings” Master's Thesis, Uludağ University, Institute of Science, Bursa.

Aziz, A.H. & Ajeel, A.E. 2010. “Effect of existing flange openings and cold joints on strength of rc t-beams” Journal of Engineering, 1, 4535-4546.

Choi, S.J., Kang, S.P., Kim, S.C. and Kwon, S.J. 2015. “Analysis technique on water permeability in concrete with cold joint considering micro pore structure and mineral admixture” Hindawi Publishing Corporation Advances in Materials Science and Engineering, 1-10.

Çomak, B., Ölmez, Ö. Ve Emiroğlu, M. 2019. “Investigation of the effect of cold joints on the dynamic elasticity modulus values of concrete” Düzce University Journal of Science and Technology, 7, 1122-1129.

Ersoy, U. & Özcebe, G. (2016). "Reinforced Concrete-1" Istanbul, Evrim Publishing House.

Illangakoon, G.B., Aamoto, S., Nanayakkara, A. and Trong, L.N. 2019. “Concrete cold joint formation in hot weather conditions” Construction and Building Materials, 209, 406-415.

Ismael, M.A., Hameed, Y.M. and Abd, H.J. 2019. “Effect of construction joint on structural performance of reinforced self-compacting concrete beams” International Journal of Civil Engineering and Technology (IJCIET), 10(1), 297-306.

Jatheeshan, V., Peiris, U., Mendis, K. and Nanayakkara, A. 2018. “Investigation of the factors affecting the formation of cold joints in concrete” 16th Annual Symposium on Research for Industry içinde (ss. 55-57). Faculty Engineering, University of Moratuwa, Sri Lanka.
Kadyrov, N. ve Yazıcıoğlu, S. 2016. “Investigation of the effect of cold joint on bending and direct tensile strength of concrete" Polytechnic Journal, 19 (3), 203-210.

Kara, C. ve Bekem Kara, İ. 2018. “The effect of different cold joint times on concrete strength” Engineering and Architecture Studies, 84-90.

Koh, T.H., Kim, M.K., Yang, K.H., Yoon, Y.S. and Kwon, S.J. 2019. “Service life evaluation of RC T-girder under carbonation considering cold joint and loading effects” Construction and Building Materials, 226, 106-116.

Laskar, S. M., Reja, H., & Talukdar, S. 2020. “Behaviour of cold jointed and layered Portland cement–alkali-activated reinforced concrete beams” Asian Journal of Civil Engineering, 21(7), 1193-1204.

Parra-Montesinos, G., Wight, J. K., Kopczynski, C., Lequesne, R. D., Setkit, M., Conforti, A., & Ferzli, J. (2017). Elimination of Diagonal Reinforcement in Earthquake-Resistant Coupling Beams through Use of Fiber-Reinforced Concrete. American Concrete Institute.

Rao Kishen, J.M.C. & Rao, P.S. 2007. “Fracture of cold jointed concrete interfaces” Engineering Fracture Mechanics, 74(1-2), 122-131.

Rathi, V.R. & Kolase, P.K. 2013. “Effect of cold joint on strength of concrete” International Journal of Innovative Research in Science, Engineering and Technology, 2(9), 4671–4679.

Roy, B. & Laskar, A. I. 2017. “Cyclic behavior of in-situ exterior beam-column subassemblies with cold joint in column” Engineering Structures, 132, 822–833.

TS EN 12390-2 Testing hardened concrete - Part 2: Making and curing specimens for strength tests

TS 708 Steel for the reinforcement of concrete - Reinforcing steel

Turan, Z. 2019. “Investigation of the effect of cold joint on mechanical and fracture behavior in concrete" Master's Thesis, EU Institute of Sciences, Izmir, Turkey.

Udoh, A. 2020. “Mechanical behaviour of concrete cold joints” Ebonyi Journal of Science, 3(1), 59-74.

Ünlü, A. 2018. “Investigation of the effect of cold joint on the mechanical properties of concrete” Master's Thesis, KTO Karatay University, Institute of Science, Konya.

Vanlalruata, J., & Marthong, C. 2021. “Effect of cold joint on the flexural strength of RC beam” Journal of Structural Integrity and Maintenance, 6(1), 28-36.

Zega, B. C., Prayuda, H., Monika, F., Saleh, F., & Wibowo, D. E. (2021). Effects of cold joint and its direction on the compressive and flexural strength of concrete. GEOMATE Journal, 20(82), 86-92.