State of the Art: Deep Beam Applications Using High-Strength Steel Reinforcement in Shear Friction.

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Abstract:

This paper's goal is to examine previous research on the application of high-strength steel reinforcement in deep beam frictional shear. It also covers the effects of force and shear on the behavior and application of this reinforcement. Shear friction is a useful property of many structures, including foundations and high-rise buildings, and it is dependent on force. It is discovered that deep beams break due to shear friction when a higher load is applied. The most common friction and failure mode in these members is shear failure. Shahnewz conducted research on deep reinforced concrete beam shear failure. Manuel et al. also looked at the effect of shear across the depth scale. The shear mode and final failure, a/h, were found to have the most influence. Shahnewz examined the shear behavior of the beams under static and dynamic loads, and Kwadwo concluded that deep concrete beams predominantly transfer large gravity loads to their supports through the shear process. Tan and Lu conducted research on the negative effects of deep beams with a/h < 1.0, concrete strength of 40 MPa, and a 2.6% reinforcing ratio. We evaluated and compared the deep beams' shear behavior as the total depth increased.

Keywords: deep beams, shear friction, RC deep beam, behavior effects force and shear, history

أحدث ما توصلت إليه التكنولوجيا: تطبيقات الحزم العميقة باستخدام حديد التسليح عالي القوة في احتكاك القص

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خلاصة:

هدف هذه الورقة هو فحص الأبحاث السابقة حول تطبيق حديد التسليح عالي القوة في القص الاحتكاكي ذو الشعاع العميق. كما يغطي أيضًا تأثيرات القوة والقص على سلوك وتطبيق هذا التعزيز. يعد احتكاك القص خاصية مفيدة للعديد من الهياكل، بما في ذلك الأساسات والمباني الشاهقة، ويعتمد على القوة. تم اكتشاف أن الكمرات العميقة تنكسر بسبب احتكاك القص عند تطبيق حمل أعلى. إن وضع الاحتكاك والفشل الأكثر شيوعًا في هذه الأعضاء هو فشل القص. أجرى شاهنيوز بحثًا حول فشل قص العوارض الخرسانية المسلحة

العميقة. مانويل وآخرون. نظرت أيضًا إلى تأثير القص عبر مقياس العمق. تم العثور على وضع القص والفشل النهائي، a/h، لهما التأثير الأكبر. قام شاهنيوز بفحص سلوك القص للعتبات تحت الأحمال الساكنة والديناميكية، وخلص كوادو إلى أن العتبات الخرسانية العميقة تنقل في الغالب أحمال الجاذبية الكبيرة إلى دعاماتها من خلال عملية القص. أجرى تان ولو بحثًا عن التأثيرات السلبية للكمرات العميقة مع1.0 > a/h ، وقوة الخرسانة 40 ميجاباسكال، ونسبة التسليح 2.6%. قمنا بتقييم ومقارنة سلوك القص للكمرات العميقة مع زيادة العمق الكلي.

الكلمات المفتاحية: العتبات العميقة، احتكاك القص، العتبات العميقةRC ، التأثيرات السلوكية، القوة والقص، التاريخ

Introduction:

In the past, structural elements with small shear/depth ratios that were loaded like beams were called deep beams. The members are loaded on one face and supported on the other such that compression supports can form between the loads and the supports. It is useful in many different buildings, including as towering skyscrapers, foundations, and naval structures. However, it works similarly, among many other things, to a unique "truss" or "tied arch" that is not generated in continuous thin beams. Two examples are floor slabs that are subjected to horizontal loads and shear walls. Most forces are transferred to the supporting locations by independent direct compression supports. The deep beam's strength is generally determined by shear, and an obvious failure is the main form of failure for such members. The shear action creates tension perpendicular to the radial direction of compression. The inability of these members to maintain loads and the likelihood of abrupt shear failure are caused by perturbations of internal stresses caused by large, focussed loads as the overall depth of the beam section increases. As a result, more study is needed on the shear behavior of deep beams with regard to several aspects, including section size. Shear strength of deep beams is directly related to section size. Several studies by Kani [1], Taylor [2], Aravin, and Lehwalter [3] have investigated the side effects of plain beams utilizing test variables such the maximum aggregate diameter and the shear span-to-depth ratio (a/h). Using the same shear span-to-depth ratio, these investigations investigated side effects at total depth and concentrated on concrete with a strength of less than 40 MPa. Taylor [4] states that when the maximum overall diameter increases in proportion to the overall section depth, the size effects become less noticeable. Tan and Lu [5] examined the shear behavior of deep beams as total depth grew in a study on the side effects of deep beams with $a/h < 1.0$, 40 MPa concrete strength, and 2.6% reinforcing ratio. They said that the Canadian CSA Code [7] forecasts provide a margin of safety for large beams with h above 1000 mm, the ACI Code forecasts are typically conservative for all beam sizes, albeit conservatism decreases as h and a/h expand, and the CIRIA [6] forecasts are dangerous for large beams. adjusted to suit beam specimens. Previous studies have also demonstrated that a decrease in network reinforcement, a maximum aggregate size, an increase in compressive strength, a decrease in the ratio of shear extension to total depth, and these factors all significantly improve ultimate shear strength. Moreover, the presence of gaps in the usual load channel causes a significant decrease in capacity.

Literature review:

Over the years, several ideas, investigations, and studies have been developed by researchers to determine the Deep Beam Applications Using High-Strength Steel Reinforcement in Shear Friction. In their investigation, they have come to a number of conclusions.

In 1971, Manuel et al. investigated how the behavior of concrete deep beams was affected by the span-to-depth ratio and the shear span-to-depth ratio (a/h). had a significant influence on the ultimate shear and failure mechanism by (a/h), but it had little effect on the depth-to-span ratio.

This study examines Yang, K.-H., and Ashour, A.'s (2008) application of the plasticity theory to reinforced concrete deep beams. The capacity of deep beams made of reinforced concrete was predicted using both the mechanism approach and the truss analogue. For reinforced concrete deep beam design, the majority of contemporary codes of practice, such as ACI 318-05 and Eurocode 2, also suggest applying the strut-and-tie approach. The mechanism analysis and strut-and-tie model are more reasonable, relatively accurate, and sufficiently simple for evaluating the load capacity of reinforced concrete deep beams when compared to techniques based on empirical or semi-empirical equations. The literature, however, reveals a wide range of values for deep beams, indicating that it may be challenging to assess the effectiveness of the concrete.

Gabriel Zeno during 2010 Evaluating the impact of high-strength steel reinforcing in shear friction applications was the main goal of the study. The process via which shear is conveyed over an interface between two smooth concrete components is known as shear friction. The roughness of the interface and the clamping force produced by the steel reinforcement that spans it are the causes. Using a cold joint test interface with surface roughness of at least ¼-inch amplitude, typical push-off specimens were tested to replicate the connection between an AASHTO girder and composite slab. The breadth of the fracture perpendicular to the test interface, the strain in the steel reinforcement across the test interface, the amount of shear load, and the shear displacement, or (slip) parallel to the test interface were all determined in these tests. The test results demonstrated that the shear friction mechanism develops gradually, with the concrete component making a considerable contribution to the shear friction capacity, and that the steel component only becomes apparent after significant cracking . Put another way, the steel and concrete components of the shear friction mechanism do not have to work simultaneously according to existing design criteria. Moreover, the test results showed that, contrary to the assumptions made by the AASHTO and ACI formulae to calculate the shear friction capacity of concrete components, the interface steel reinforcement never reaches its yield strain. As a result, applying high-strength reinforcing steel has no effect on shear. has no effect on the shear resistance of concrete components since the shear resistance mechanism's clamping is primarily determined by the steel's elastic modulus rather than its yield strength. On the basis of these discoveries and the experimental data from recent and previous testing, a different equation is suggested for the calculation of the shear friction capacity of reinforced concrete members.

In 2013, Hawrazkarim M. Amin and colleagues investigated how the positions and sizes of openings affected the shear strength behavior of deep reinforced concrete beams without web reinforcement. The size and location of the opening were the main factors taken into account in this work. Consideration is given to variations in factors (l/d, a/d, fc, and maximum aggregate size) that affect the behavior of deep beams made of reinforced concrete. Using a nonlinear analysis using the finite element approach, the ultimate shear and mechanism of failure for reinforced concrete deep with apertures were predicted. Nonlinearities in the materials caused by the yield conditions of the reinforcing steel and the crushing and cracking of the concrete were also taken into account. Eleven experimental deep beams composed of reinforced concrete that were not open were examined in order to evaluate and demonstrate the capabilities of the suggested model. The position of the apertures was found to have a substantial effect on the results. The shear zone, where a steep decrease in ultimate Shear was recorded, had the highest, while the mid-span site exhibited the smallest effect. In each model to be examined, the experimental deep beams were constructed with square web apertures of three sizes at three different positions.

2013 saw Shahnewaz, Md. The breakdown of a deep reinforced concrete (RC) beam in shear is sudden, brittle, and can have catastrophic consequences. It is consequently crucial to accurately determine the shearing behavior of RC deep beams under both static and dynamic pressures. In this work, a modern experimental database for deep beam failure under static stresses in shear is built. After then, reliability analysis was used to calibrate

the equations for design purposes. The resistance of the design equations were determined to acquire a target dependability index of 3.5 in order to achieve an acceptable degree of structural safety. A deep beam section that was built by building with just static loads in mind may respond differently when dynamic loads are applied.

In 2014, P. Attarde and D. Barbat The structural behavior of RC deep beams is examined in this study using a variety of methodologies. The span-to-depth range of deep is 1.5 to 2.5. The tests and literature study presented here address the analysis of deep beams using steel fiber, HSSC, and other materials under loading scenarios. The typical inclination is to look at failure modes and load-deflection characteristics.

In 2015, Kwadwo Adinkrah-Appiah and colleagues Shearing action is said to be the primary method by which heavy gravity loads are conveyed to the supports of reinforced concrete deep beams. Deep beams should have high ductility and shear strength. Regarding RC deep beams, different academics have proposed different definitions and theoretically different standards of practice. Furthermore, utilizing extensive and analytical test programs, several academics have developed a number of methods and prediction models to determine the shear strength of beams. The strut-and-tie model (STM) and the ACI-318 (2008) code definition are the most useful definitions and shear capacity for the classification and shear strength prediction, according to the study's analysis of the definitions and shear capacity models of deep beams in accordance with various code provisions.

Yassin, Sinan Abdul Khaleq et al. (2017) High-performance deep reinforced concrete beams' shear strength is predicted by neural network models. The neural network model is based on 233 literature packages that consider multiple factors, including the span-to-depth ratio, the concrete's strength, the quantity of longitudinal reinforcement, and so forth. A neural network can be a useful tool for predicting the shear capacity of deep concrete beams, both ordinary and high-strength. With a correlation coefficient of 0.836, the projected shear strength of the neural network closely the experimental results. The shear force model for the ACI design equation generated by the neural network was proposed by Aziz and Zsouti. in contrast to the Aziz and Zsoti equations and the ACI Code equations. in contrast to the Aziz and Zsoti equations and the ACI Code equations. Studies showed that the neural network approach accurately captured the effect of concrete compressive strength on the shear capacity of deep-reinforced concrete beams lacking shear reinforcement.

In 2018, Devine, Robert D. et al. released an experimental examination of the independent and combined effects of high-strength steel and concrete on the behavior of stocky reinforced concrete structures. Four cantilever deep beam specimens, which represented slices along the length of a prototype stocky shear wall without border areas or members, underwent a series of monotonic lateral load tests. The specimen composed of both high-strength steel and high-strength had the largest lateral strength and deformation capacity, illustrating the benefits of high-strength concrete when used in stocky buildings.

2020 will see Hassan Falah and Yaarub Abtan Deep beams made of reinforced concrete are structural components that have a depth that is noticeably greater than usual compared to their span and a thickness that is noticeably thinner perpendicular to the span or depth. Shear frequently controls the strength of deep beams, as opposed to flexure. This study will examine previous studies on concrete deep beams. This inquiry started about the middle of the previous century. Many researches have determined the capacity and studied the behavior of concrete deep beams. While some of these works examine numerous deep beams with properties through experimental methods, others determine the capacity of deep beams by theoretical methods.by developing a few hypotheses, providing methods for calculating their capability, and contrasting them with those employed by specific programs.

2020 Saif Aldabagh and partners Due to its notably higher strength and corrosion resistance than standard steel, like ASTM A615 Grade 420, high-strength steel (HSS), and ASTM A1035 Grade 690 in particular, has been employed increasingly frequently throughout the previous 20 years. Because HSS lacks defined yield point and yield plateau, it displays a different stress-strain response than traditional Grade 420 steel. Therefore, a great deal of study has been done to determine whether the design parameters are sufficient even for yield strengths of up to 690 MPa and to assess the performance of HSS reinforcement in structural concrete. This publication provides a systematic synthesis along with associated research endeavors. Lastly, to allow designers to fully reap the benefits of the benefits of HSS reinforcements, it is advised that future research enhance the stipulated yield strength of HSS in certain applications.

Rasha T. S. Mabrouk and colleagues in 2021 The aim of this work is to investigate the effects of aperture size and position on deep beams. The analysis of deep beams with openings presents a difficult challenge for engineers because there are no standards for this topic in the design codes yet.

Utilizing the strut is a feasible alternative that also adds some uncertainty, the fact that there are other models that can be used. This research suggests using a form of strut and ties idea in the deep beams with apertures where reinforcement is structured as embedded struts and ties. The inquiry is divided into two parts: an experimental section and a numerical section. Eight deep reinforced concrete beams were used in the experiment, which was conducted under vertical weights. Seven of the specimens had web apertures of different sizes and locations, with the exception of the eighth specimen, which was a reference beam without any perforations. The web's apertures were measured to be 150 and 300 mm long, and their placement varied between 0.11 and 0.4 of the span. Each beam was made of concrete and the same requirements. In contrast to the experimental findings, a numerical analysis was carried out using a finite element program, taking into account the modes of failure, load-deflection behavior, and cracking pattern. To find out how the reinforcement surrounding the apertures and their placement affected the behavior of deep beams, parametric research was conducted. In light of the outcomes, The results showed that the location of small gaps had no effect at all on the strength of the beam, whereas large web perforations that cut right through the compression strut caused the most reduction in beam capacity.

2022 saw Ayad Zaki Saber. Updating the requirements in standard codes is one way to improve the structural design of concrete, particularly when non-traditional materials are being used for concrete beams. Therefore, this work primarily focuses on the differences between high-strength concrete beams with and without steel fibers in terms of compressive and shear strengths. In order to achieve this, a number of models that incorporate different combinations of the main variables—beam dimensions (effective width and depth), reinforcement index, concrete compressive strength, and shear span ratio—have been proposed to predict the shear strength of high-strength concrete beams as well as the properties of steel fiber (kind, volume content, and fiber aspect ratio). Using the empirical findings from the sizable database included in the study, both linear and nonlinear multiple regression are performed. The various models that are accessible through publications, standards, and codes represent the anticipated outcomes of the suggested equations.

In 2023, Qasim Muhammad Shakir conducted a thorough examination of the theoretical frameworks and methodologies put forth in the literature to look into the behavior of RC corbels. Neural networks, the strut and tie model, finite elements, and the shear friction were some of these techniques. The evaluation was expanded to encompass the experimental studies conducted by scholars and investigators to examine the response of RC corbels. Finally, the

assessment included a number of suggestions for strengthening and repairing RC corbels. A range of materials, such as composite sections, NSM CFRP bars, FRP composites, steel fibers, and NSM steel bars, were used to increase the performance of RC corbels. The most findings have been compiled. Additionally, a number of suggestions have been made to expand the study of the RC corbel in order to better understand how this important structural component functions.

Augustino Daudi Salezi et al., 2023 Deep concrete beam design has been significantly updated in the modern day by the use of computer-aided tools, especially with the development of technology. However, it's important to understand the basic principles underlying this kind of construction, especially when the beam has slots. The mechanical properties of deep-slit beams must be strengthened with steel fibers made from recycled tires. For fiber lengths of 30, 50, and 60 mm, concrete shrinkage strains at a content of 0.5% were taken into consideration to assess the bond strength of the fiber-concrete, improve deep beam design, and reduce the conservation of specific potential shear patterns. The model was generated using a simplified compressed stress block.forces inside the reinforcement as well as shear stress at the concrete fiber. Studies have shown that the addition of fibers to concrete enhances the shear performance of deep-crack concrete beams because the addition of fibers causes the shear zone to undergo strains, an indication of the transfer of heavy loads. Deep-hole concrete beams and steel fiber beams can be precisely designed with this model.

Conclusion:

• Deep beams are structural elements loaded as simple beams, but a compression force that combines the load and the reaction carries a significant percentage of the load to the supports. This implies that the strain distribution is no longer thought to be linear and that shear deformations become significant as compared to pure flexure.

• Prior studies have demonstrated that the ultimate shear strength is greatly increased by increasing the network reinforcement, compressive strength, maximum total volume, and reducing the extension or shear to total depth ratio.

According to some scientists, 2.6% of the steel used for reinforcement is made of steel. These researchers examined and contrasted deep beam shear behavior at all depths.

• The researcher, Ayad Zaki Saber, discussed how to improve the design of concrete structures and update the standards codes' list of requirements. The researchers' tests also focused on the differences in compressive and shear strengths between high-strength concrete beams with and without steel.

• Previous studies on deep concrete beams have shown that the thickness in the vertical direction is substantially less than the depth or span; this study will assess those findings.

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