State of Art: Redistribution of Moment in Continuous Beams: A Comprehensive Analysis

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Abstract:
Reaction forces are generated by the loads applied to the beam at its support points. There are internal stresses, strains, and deflections in the beam as a result of the shear forces and bending moments created by all of the forces acting on it together. In this paper, the idea of redistribution of moment was reviewed. that is used to reduce the amount of maximum moment that occur in the structures. The hinge's ability to distribute internal bending moments inside the structure is demonstrated by its ability to withstand additional load once it has developed. Here we have redistribution of moments. A continuous reinforced concrete part, often a beam, can enhance structural efficiency by redistributing internal bending moments through a process known as moment redistribution. Hinge rotation is possible because of the materials' suitable degree of ductility.

Keywords: moments redistribution, cracking, flexural behavior, ductility.

إعادة توزيع العزوم في عوارض مستمرة: تحليل شامل

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الخلاصة:
تتولد قوى رد الفعل من الأحمال المطبقة على العارضة عند نقاط المساند . هناك ضغوط وانفعالات وانحرافات داخلية في العارضة نتيجة لقوى القص وعزوم الانحناء الناتجة عن جميع القوى المؤثرة عليها معًا. في هذا البحث تم استعراض فكرة إعادة توزيع العزم. يتم استخدامه لتقليل مقدار العزم الأقصى الذي يحدث في الهياكل. تتجلى قدرة المفصل على توزيع عزوم الانحناء الداخلية داخل الهيكل من خلال قدرتها على تحمل الحمل الإضافي بمجرد تطورها. هذا يعرف ب إعادة توزيع العزوم. يمكن للجزء الخرساني المسلح المستمر، والذي غالبًا ما يكون عارضة، أن يعزز الكفاءة الهيكلية عن طريق إعادة توزيع عزوم الانحناء الداخلية من خلال عملية تعرف باسم إعادة توزيع العزوم. يمكن تدوير المفصلة بسبب درجة الليونة المناسبة للمواد .

Introduction

The most prevalent structural forms are concrete elements that are statically indeterminate in the area of structural engineering, where reinforced concrete (RC) constructions are commonly used. Precise internal force analysis of reinforced concrete structures is necessary to study structural behavior and design. Nonlinear analysis, plastic analysis, and linear elastic analysis are the three primary categories into which the analysis approaches may generally be divided. The accuracy of these categories is listed in ascending order [1]. The members' flexural stiffness is maintained throughout the computation of the internal forces in the linear elastic analysis, which treats the concrete and reinforcement as elastic materials. This approach has the benefit of being easy to use and precise enough before the concrete fractures. The behavior of a reinforced concrete part in real life cannot be adequately simulated by an elastic model, though, since the flexural stiffness of concrete changes as cracks grow and form [2] .There are differences between the elastic and actual moments. The degree of deviation is constantly changing in tandem with variations in the relative flexural stiffness. Momentum moves from one section to the others as soon as the continuous beam generates a collapse mechanism. This is true—the hinge's actual moment remains almost constant during rotation, especially when the reinforcement yields and becomes a plastic hinge. Moment redistribution is the term for this process [3] .Moment redistribution mechanics is complicated by the inelastic nature of reinforced concrete. The flexural stiffness is significantly reduced throughout this process, leading experts to conclude that the rotation of the plastic hinge area mostly determines the degree of moment redistribution [4].

Literature review

Nethercot al el (1995)[5] presented numerous batches of numerical results that have been produced for modifications in critical factors known to influence behavior, utilizing the prior theoretical approach devised to predict the needed rotations in the composite frame's support areas. Correlation analyses were performed using these numerical results to identify the most important parameters influencing the necessary rotations. Empirical equations that directly connect the to provide the maximum strength of composite beams, rotation requires to the degree/of moment redistribution were obtained by utilizing regression analysis and the governing parameters. Numerical results defining feasible rotation condition and, consequently, the grade of moment redistribution, are presented based on these equations.

Chien-Hung Lin al el (1999)[6] showed that after comparing the analytical and experimental data, it was determined that the analytical results were satisfactory. It suggests that more moment redistribution and increased ductility will result from decreasing tensile reinforcement and increasing compression reinforcing.

Scott al el (2005)[7] The research contended that a substantial segment of this redistribution will invariably transpire at the serviceability limit state (SLS). This is because of the disparity between the flexural stiffness presumed in the computation of ULS moments and the one that transpires at SLS, which is caused by variations in the arrangement of reinforcement throughout the member and the influence of progressive cracking.

The paper provides an analytical demonstration of this and makes observations on the current member stiffness requirements in BS 8110. The tests performed on thirty-three duble-span beams are then made available. Examined were redistribution values, beam depth, configurations of reinforcement, concrete strength as well and the impact of the brittle reinforcement. The results demonstrate that the SLS has substantial redistribution and that there is room to expand the redistribution allowance beyond what is currently allowed by design rules. Further modeling validates the idea that, although being shown to be a limiting factor, fracture width issues may become important.

Shakir al el (2005)[8] investigate a significant factor that affects the High-strength concrete (HSC) members' ductility; a result, is reasonable to assume that this parameter will also have a notable impact on the moment redistribution in these pieces. The current study looks at the accuracy of this "common-sense knowledge. An experimentally verified nonlinear model is used to conduct a computational experiment on continuous reinforced HSC beams with two spans and confinement ". According to the findings, confinement has a different impact on moment redistribution than it does on flexural ductility. Assuming the formation of both the positive and negative plastic hinges after failure is found that redistribution in the ultimate limit state is almost independent of incarceration. Tests conducted on prototype HSC beams agree with the numerical results. We assess a number of design codes. As opposed to the American Concrete Institute (ACI) code, The influence of confinement on moment redistribution in reinforced HSC beams is demonstrated to be adequately described by the code equations developed by the British Standards Institution (BSI), the Canadian Standards Association (CSA), and Eurocode 2 (EC2).

Aiello al el (2007)[9] highlight the results of tests done on continuous beams of steel-fiber-reinforced concrete (RCC) with and without external reinforcement. In order to allow for steel yielding before the beams collapse, the internal flexural steel reinforcement was designed. made of steel were employed to stop the shear failure. Two non-strengthened control beams were also a part of the tests; the other specimens were strengthened using various externally bonded carbon-fiber-reinforced polymer (CFRP) laminate arrangements. Additionally, wrapping was used to stop the CFRP strengthening from delaminating and failing prematurely. The observed practical results validate the results from two basic computational models by demonstrating that a suitable choice of strengthening configuration can lead to a significant degree of moment redistribution.

Maghsoudi al el (2009)[10] demonstrated that the ductility of continuous concrete beams permits the transfer of moment between the positive and negative moment zones. Even yet, a lot of in situ reinforced high-strength concrete beams are continuously constructed. When compared to the ultimate load enhancement ratio in the identical beam, the moment enhancement ratio of the reinforced beams was noticeably greater.

Tiejiong Lou al el(2014)[11] offer the analysis he following article provides an analysis of the redistribution of moments in continuous beams composed of normal strength concrete (NSC) and high strength concrete (HSC). The findings of ongoing experiments using HSC specimens are used to validate a nonlinear computer model that is presented. To cover both NSC and HSC beams, Concrete strengths ranging from 30 to 90 MPa are tested numerically on continuous two-span beams. Different ratios of tensile steel are employed over the midspan and center support. A few moments redistribution rules are analyzed. The analysis verifies that the stiffness of the key portions affects the moment redistribution. Furthermore, the results indicate that complete In HSC beams, moment redistribution is more likely to occur than in NSC beams. outcomes derived from a parametric.

Niklas Bagge al el(2014)[1] described an experimental program that evaluated twelve two-span reinforced concrete beams and included a theoretical analysis of the beams' ability to support a given weight. The redistribution of internal forces over the entire load history of the tested beams was thoroughly investigated. In the early stages of the load process, Flexural stiffness variation caused by the actual arrangement of the reinforcing steel and concrete crack formations resulted in moment redistribution, which was observed.

Lou al el (2017)[12]Discuss the importance of relative stiffness as given by the structurally relevant parameter $\rho s2/\rho s1$, which represents the distribution of moments in large-strength reinforced concrete beams. The positive , negative tensile steel ratios are denoted by $\rho s1$ and $\rho s2$, respectively. the second region in a row). Continuous double-span beams composed of HSC material with a cylindrical compressive strength of 90 MPa were subjected to numerical examination. By adjusting $\rho s1$ or $\rho s2$, a broad range of $\rho s2/\rho s1$ was obtained, ranging from 0·81% to 6·06%. The findings indicate that a crucial factor affecting the global moment redistribution behavior is the $\rho s2/\rho s1$ ratio. It is suggested to make adjustments to the American Concrete Institute and Canadian Standards Association formulae in order to compute the moment redistribution in the final state. It is demonstrated that the suggested updated equations have a great match to the real redistribution values by adding the parameter $\rho s2/\rho s1$.

Visintin al el(2018) [13]proposed the notion of redistribution of moment is used in the design of statically indeterminate structures to minimize the absolute magnitudes of moments in critical regions, to utilize non-critical cross sections to their full potential, as well as to simplify details by permitting a decrease in reinforcement ratios. Given that complex processes control how plastic hinges develop and rotate ,moment redistribution capacities are typically derived through empirical means and may not be universally applicable beyond the confines of the testing regime. The goal of this study was to determine the moment redistribution capability of four ultra-high performance fiber reinforced concrete (UHPFRC) beams with two spans and varying reinforcement ratios. The experimental results are presented in this publication. The findings demonstrate the potential for expanding the existing empirical design.

Ling Li al el (2019)[14] The study discovered that moment redistribution is a unique phenomena observed in statically indeterminate reinforced concrete structures, with relation to the structural redundancy of reinforced concrete and its nonlinear properties. Designing for moment redistribution is a useful approach to maximize the capacity of the material reserve and make construction easier.

Da Luo al el(2023)[15]proposed a relationship between the ductility and stiffness distribution of the redistributed section over the entire beam and moment redistribution (MR), a nonlinear feature occurring in continuous reinforced concrete (RC) beams. The use of high-strength rebar (HSS) may have an effect on the ductility of the redistributed section and may delay or stop the development of successive plastic hinges altogether. One of the things that prevents design engineers from using HSS is the scarcity of information about how such events affect MRI. A new approach that takes into account the yield state to calculate the MR power of continuous beams is proposed. The reasonable accuracy of this approach has been demonstrated. For every 100 MPa increase in the yield strength of the reinforcement, it is recommended to reduce the stipulated MR by approximately 6%.

Udaya Bhaaskar Bulusu (2023)[16] It is found that the moments can be redistributed if the forces and moments are analyzed according to linear elastic behavior. In the working stress design method, analysis by linear elastic behavior is a logical step where the material behavior is assumed to be linearly elastic up to the level of suggested safe stresses in the design concept. Nonetheless, there appears to be a contradiction between design utilizing the limit condition of collapse and analysis utilizing linear elastic theory.

Conclusion:

By looking through the literature, it was discovered that the loads placed on the beam result in forces and reactions at both its support and terminal locations. Shear forces and internal bending moments cause internal stresses, strains, and deflections in the beam as a result of all the forces operating on it. The process of moving internal bending moments inside continuous reinforced concrete members—typically beams—in order to increase structural efficiency is known as moment redistribution. Internal bending moments can be transferred within the structure when further load is applied or after the hinge has developed. This phenomenon, referred to as moment redistribution, is enabled by the appropriate degree of ductility of the materials.

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