

Experimental Investigation of Flexural Cracks in Light Reinforced Concrete Beam

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Abstract — This study investigates the flexural crack behavior of lightly reinforced concrete (RC) beams through experimental analysis. Six beams with varying reinforcement ratios and dimensions were subjected to three-point bending tests to understand the crack initiation, propagation, and branching phenomena. Materials were characterized through standard tests, and the beams were cast with M30 grade concrete, reinforced using high-yield strength deformed bars. A notch was introduced at mid-span to ensure controlled crack initiation. The experimental observations showed that reinforcement influenced crack branching and ductility behavior significantly. Beams with higher reinforcement ratios exhibited delayed crack propagation, greater energy absorption, and enhanced ductility, while unreinforced beams failed through a single dominant crack. Crack width development and crack mouth opening displacement (CMOD) were monitored using high-resolution imaging and microscopic tools. The study concludes that crack branching contributes to increased ductility by redistributing stresses during failure and that beam depth and reinforcement ratio critically affect the crack propagation mechanism. The results emphasize the importance of crack control and ductility enhancement in the design of lightly reinforced concrete structures, providing a foundation for improved fracture modeling and structural resilience.

Keywords: Flexural Behavior, Crack Propagation, Lightly Reinforced Concrete (LRC), Three-Point Bending Test, Crack Branching, Ductility Enhancement, Crack Mouth Opening Displacement (CMOD), Reinforcement Ratio, Fracture Mechanics, Structural Resilience

I. INTRODUCTION

When compared with its characteristic strength, the concrete is a semi weak material having poor rigidity. It is therefore weak and helpless of breaking. The breaking system in concrete is confounded, by the way, in that the break is inadequately harmed zone and some pressure exchange capacity in the deformation region of the crack exists. A progress region called FPZ is located between the recent person of the open break and the unaffected flawless material behind it. Although there is discussion as to what constitutes a FPZ and how big it should be, everybody agrees that it takes place in concrete [1]. Understanding of harm frameworks and improvement of the conduct of huge structures rely upon the capacity to judge and improve the conduct of the FPZ. Support in built up concrete influences the advancement and acceleration of breaks by satisfying them into the break cycle. Generally, the breaking system depends on the arrangement of breaks, break spread, the nearness of breaks, the association among backing and cement, also the little structure of the significant, i.e. concrete and complete [2].

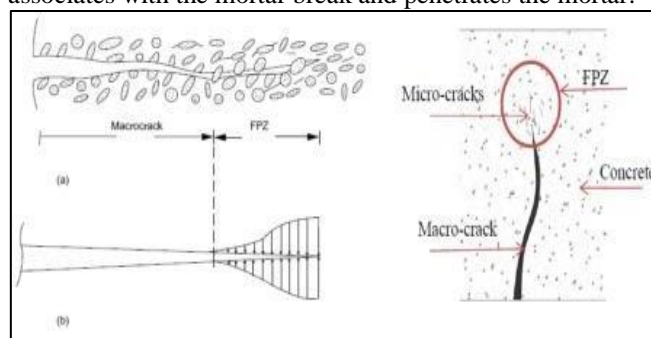
Amongst these factors ... the compressive strength of the considerable, the sort, attributes, and proportion of longitudinal bolster, the association between the bolster and the considerable, and the numerical characteristics of the pillar altogether, might possibly effect the break system and bolster break extending. In addition, these variables may be interdependent and interlocked.

II. INTRODUCTION & SCOPE

For many decades, there have existed numerous studies of concrete cracking, models developed to estimate the breaking system in constructed cement footers. An extensive length of the time has been devoted to versatility-based models (which are adaptable according to the twofold reason for adaptable conduct, for example, PM's with adequate internal steel or break metal-based displays that don't consider break as a point event however utilize break metal guidelines to clarify break development). In the concrete the presence of minute cracks and microcracks along with macrocracks hampers the cracking tendency. It also occurs due to strain localization and bridging. Typically, in a strength criterion analysis, the behavior is explained using continuous variables. In contrast, during break spread, the conduct is dictated by what occurs in the break cycle zone (FPZ) in front of the break tip, a rated on wrong zone with a few leftover pressures move capacities.

III. THE FORMATION OF CONCRETE CRACKS

Because cementitious materials, including pastes, mortars, and concretes, are complex, heterogeneous materials, it is useful to entertain how properties change with particle structure. Mechanical characteristics of cementitious materials are much controlled by defects. For example, microcracks are common in concrete before it is loaded; at places, pores around the associate of the coarse particles and mortar. The significant mortar contracting is the way that they are brought about. In addition, there are breaks in the mortar network. And as a heap is applied on that single and repeatedly, the two earlier bursts of growth continue ever growing and new bursts emerge. This breaking interface associates with the mortar break and penetrates the mortar.



IV. A UNIQUE BENDING CRACK

In a flexural crack, the crack path is 90 degree of applied tensile stresses (Figure 1.2). As a result. A Mode I crack propagation is an opening type, such that load is normal to the crack plane & rotating around the crack tip at the same time.



However, contrasted with other modes, research centers have an inclination to try mode I cracks, because such tests are basic to lead. Because mode I inability of supported cement footers may be seen as an inclined break as opposed to mode II, mode I results likewise give information to hypothetical examinations of shear disappointment.

V. OBJECTIVES

This research is carried out to investigate in depth the cracked movement in RCC beams. Experimental studies will be employed that will observe the actual cracking analysis of the R.C beaming itself. Specifically, the project strives for the following goals:

- To study the effect of reinforced on the movement of cracked concreted beaming.
- We aimed to investigate the effects of D of beam on the depth of fracture.
- To test the influence of both beam D & steel on the durability of RCC beams .
- It was aimed at seeing the effect of crack depth on durability of concrete

VI. STEPS IN METHODOLOGY



VII. EXPERIMENTAL INVESTIGATION

A. Properties Materials Used

Material sampling was used to confirm the quality that will be used for casting. Physical test-outs are done on cement and also on fine and coarse aggregates.

B. Cements

In this project, general port landing cementing, G- 43 was used. Some of the tests evaluated the qualities of cement as represented by the following.

C. Consistency As a Standard

According to the ASTM standards, a standard consistency of cement paste is the moisture content with which a Vicat's plunger having an approximate dia 10.000 mm & an approximate length 50.00 mm is penetrated a maximum of 33.00–35.00 mm from the upper part. For instance, the testing is used to establish the start & final setting times, but most importantly. It was found that the water was 30.00%.

Test no	W/C	Plunger Depth
1.0	0.255	165
2.0	0.275	275
3.0	0.295	320
4.0	0.295	33.4
5.0	0.300	34.8

VIII. CONCLUSION

It conducted experiments on cracking behavior in reinforced concrete (R.C.) beams on two points: Localized zone and the crack branching process. As follows, the findings from theses experiments have been summarized and analyzed.

Nonreinforced concrete beams: A single slightly curved band of crack signals that material degradation has started to take place. The load capacity decreases as the load increases and the beam has increasing vertical deflection beyond the peak load, it is a softening behavior. On the softening phase the crack mouth aperture grows very much, implying that the material deteriorates further under stress.

In reinforced concrete beams, the cracking will first appear as a narrow curved band. However, the presence of the reinforcement prevents early fracture, so that crack branching is favored. The first event occurs when a single crack breaks into two different branches. Localised failure in the compressed zone of the beam occurs from the interaction of the bifurcated cracks.

IX. REFERENCES

- [1] Mindess S. “*The fracture process zone in concrete*”. In: Shah S, editor. “*Toughening mechanism of quasi-brittle matter*”. Dordrecht: Springer, Netherlands; 1991, p.271–86.
- [2] Hillerborg A, Modéer M, Petersson PE. “*Analysis of crack formation and crack growth in concrete by means of fracture mechanics and finite elements*”. Cem Concr Res 1976;6:773–81
- [3] Carpinteri A, Massabo R. “*Continuous vs discontinuous bridged-crack model for fiber-reinforced materials in flexure*”. Int J Solids Struct 1997;34:2321–38.
- [4] Wu Z, Rong H, Zheng J, Xu F, Dong W. “*An experimental investigation on the FPZ properties in concrete using digital image correlation technique*”. Eng Fract Mech 2011;78:2978–90.
- [5] Carpinteri A. “*Stability of fracturing process in RC beams*”. J Struct Eng 1984;110:544–58.
- [6] Vejt I, Breugel V, Weerheijm J. “*Failure mechanisms of concrete under impact loading*” Fract. Mech. Concr. Struct. Fram., 2007, p. 579–87.
- [7] Beeteo V. “*Ductility based structural design*”. In: Proc. Ninth World Conf. Earthq. Eng. Tokyo-Kyoto, Japan, Tokyo-Kyoto, Japan; 1988.
- [8] Park R. “*Evaluation of ductility of structures and structural assemblages from laboratory testing*”. Bull NZ Natl Soc Earthq. Eng 1989; 22:155–66.
- [9] Skarzynski Ł, Syroka E, Tejchman J. “*Measurements and calculations of the width of the fracture process zones on the surface of notched concrete beams*”. Strain 2011;47:319–32.
- [10] Alam SY, Loukili A, Grondin F, Rozière E. “*Use of the digital image correlation and acoustic emission technique to study the effect of structural size on cracking of reinforced concrete.*” Eng Fract Mech 2015;143:17–31