FLEXURAL RESISTANCE IN RECTANGULAR CONCRETE BEAM WITH MAXIMUM TENSION REINFORCEMENT

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BY

WONG SIE KWONG

SUMMITED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE BARCELOR OF ENGINEERING (HONS.) IN CIVIL ENGINEERING.

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APPROVAL SHEET

This Final Year Project Report entitled "FLEXURAL RESISTANCE IN RECTANGULAR CONCRETE BEAM WITH MAXIMUM TENSION REINFORCEMENT" prepared and submitted by WONG SIE KWONG in partial fulfillment of the requirement for Bachelor of Engineering (Civil) is here by accepted.

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ABSTRACT

When a concrete beam is subjected to loading, the entire cross section of the beam resists bending, with compression on top and tension at the bottom. The reinforcing steel is provided to resist the tensile stress. BS 8110 (1985) recommends that the maximum amount of steel provided in the reinforced concrete should not exceed 4% of the cross sectional area of the beam section. Therefore the intension of this project is to study the flexural resistance in rectangular reinforced concrete beam with maximum tension reinforcement. These involve analytical calculation of flexural strength of reinforced concrete beams with maximum reinforcement, evaluation of mode of failure and determination of the necessity of additional and amount of compression reinforcement required to achieve the ductility requirement as recommend in BS 8110 (1985).

ABSTRAK

Apabila rasuk konkrit dikenakan beban, keseluruhan keratan rentas rasuk menahan kelenturan dengan mampatan di bahagian atas dan tegangan di bahagain bawah. Tetulang keluli diperuntukkan untuk menahan tegasan tegangan. BS 8110 (1985) mencadangkan bahawa jumlah maksimum tetulang keluli yang diperuntukkan dalam rasuk konkrit bertetulang supaya tidak melebihi 4% daripada luas keratan rentas rasuk. Oleh itu, tujuan projek ini adalah untuk mengkaji ketahanan lenturan dalam rasuk bertetulang segiempat dengan tetulang tegangan maksimum. Ini merangkumi pengiraan analitikal ketahanan lenturan bagi rasuk konkrit bertetulang, pernilaian sifat kegagalan, dan penentuan keperluan tambahan serta jumlah tetulang mampatan yang diperlukan untuk mencapai keperluan kemuluran seperti mana yang dicadangkan oleh BS 8110 (1985).

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LIST OF NOTATIONS

A_s	Cross sectional area of tension reinforcement
A_s'	Cross sectional area of compression reinforcement
b	Width of the section
d	Effective depth of tension reinforcement
d'	Depth to compression reinforcement
E_s	Modulus of elasticity of steel
f_{cu}	Characteristic concrete cube strength
f_y	Characteristic strength of reinforcement
f_s	Steel stress
F_{cc}	Resultant compressive force in concrete
F_{st}	Resultant tensile force in tension reinforcement
h	Overall depth of the section in plane of bending
M	Bending moment
M_R	Moment of resistance
s	Depth of equivalent rectangular stress block
x	Neutral axis depth
z	Lever arm

ε_s **Steel strain**

ε_{cc} **Concrete strain**

ε_{st} **Strain in the tension steel**

ε_{sc} **Strain in the compression steel**

γ_f **Partial safety factor for load**

γ_m **Partial safety factor for material**

CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTION

Reinforced concrete may be the most important materials available for construction industry. It is a composite material of steel bars embedded in a hardened concrete matrix. It can be formed into varieties of shapes and sizes. Its utility and versatility is achieved by combining the best features of concrete and steel. Concrete and reinforcing steel have widely different properties and are more or less complementary. Concrete is strong in compression but week in tension. When they are combined, the steel is able to provide the tensile strength and probably some of the shear strength while the concrete, strong in compression, protect the steel to give durability and fire resistance.

1.2 CONCRETE STRESS-STRAIN RELATIONSHIP

Concrete is a very variable material having wide range of strengths and stress-strain curves. A typical curve for concrete in compression is shown in Fig.1.1. As the load is applied, the ratio between the stress and strain is approximately linear at first and the concrete behaves almost as an elastic material with full recovery of displacement if the load is removed. Eventually, the curve is no longer linear and the concrete behaves more as a plastic material. There will be no more full recovery and a permanent deformation would remain even after the load is removed. The ultimate strain for most structural concretes tends to be a constant value of approximately 0.0035, irrespective of the strength of concrete (Mosley and Bungey, 1990).

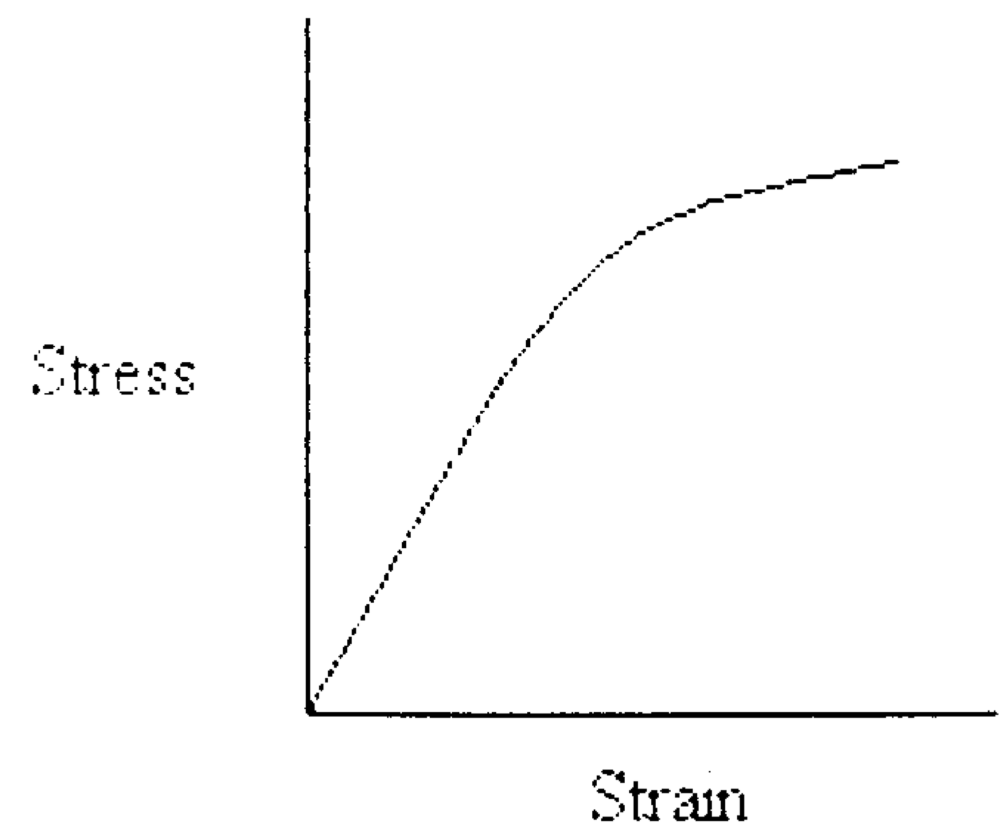

Fig 1.1 Typical stress-strain curve for concrete in compression

1.3 STEEL STRESS-STRAIN RELATIONSHIP

Fig. 1.2 shows a typical stress-strain curves for (a) mild steel and (b) high yield steel. Mild steel behaves as an elastic material, with the strain proportional to the stress up to the yield strength. After the yield point, mild steel becomes a plastic material and the strain increase rapidly up to the ultimate value. High yield steel on the other hand does not have a definite yield point but shows a more gradual change from elastic to plastic behavior.

The specified strength used in the design is based on the yield stress for mild steel, whereas for high yield steel the strength is based on a specified proof stress. A 0.2 percent proof stress is defined in Fig. 1.2 by broken line drawn parallel to the linear part of the stress strain curves (Mosley and Bungey, 1990).

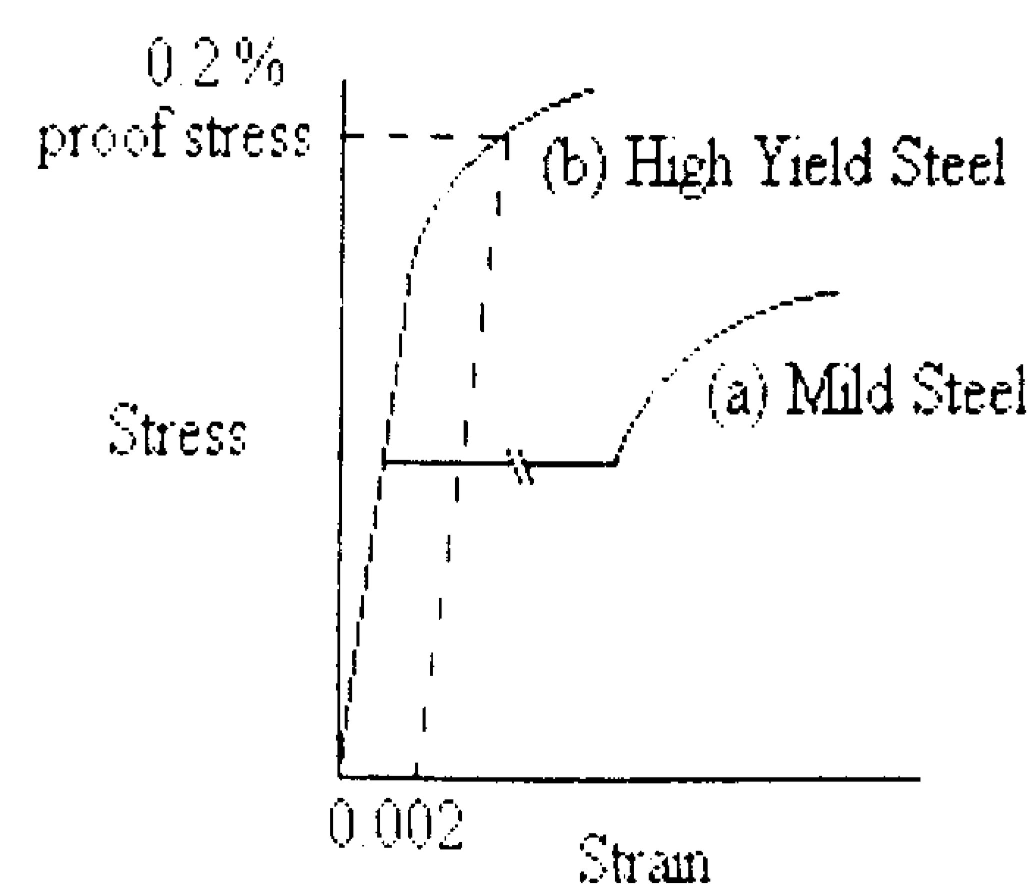

Fig 1.2 Stress-strain curve for steel

1.4 CONCRETE WITH REINFORCEMENT

When a concrete beam is subjected loading, the entire cross section of the beam resists bending, with compression on one side and tension on the other. As the load increases, cracks start to developed at bottom as shown in Fig. 1.3. The cracked concrete cannot resist tensile strength. The reinforcing steel is provided to resist the tensile stress.

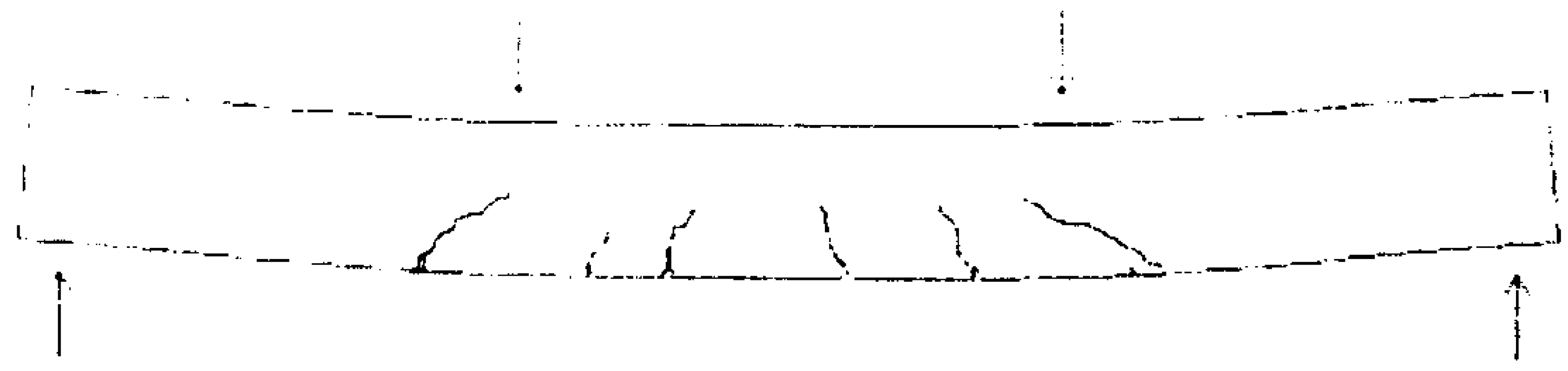

Fig. 1.3 Beam cracks under load

At this stage, the compressive stress in the top fibers is less then the concrete compressive strength, f_{cu} and as long as the steel stress, f_s is less than its yield points. The stress-strain for this range is shown in Fig. 1.4. The compressive stresses vary linearly with the distance from the neutral axis as a straight line.

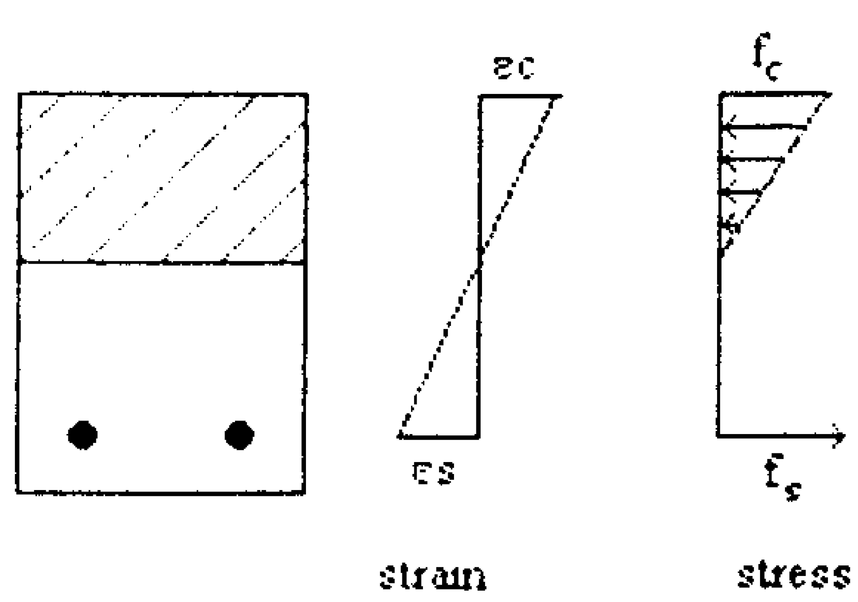

Fig. 1.4 Stress-strain for section with reinforcement

The amount of steel provided has great influence on the mode of failure. A beam that has a balanced steel ratio is the one for which the tensile steel will theoretically start to