THE EFFECT OF ECCENTRICITY AT BEAM SUPPORT TO BEAM STIFFNESS

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To my beloved sister, brothers and relatives, thanks for endless support.

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ABSTRACT

A beam reacts to loading through bending action. Therefore, beam bending stiffness can be represented by deflection. Theoretically, beam stiffness is governed by span length, elastic modulus, moment of inertia and support type. In the analytical analysis, beams are assumed simply supported or fixed supported However, based on real cases and lab experiments there are other factors that are not included theoretical equation but effect to the beam stiffness Factors such as eccentricity between beam neutral axis and beam support (vertical eccentricity), pour stop stiffness in composite beam/slab effect and column size effect were analyzed in this study. The effects were studied using plane stress element finite. Pour stop stiffness were modelled using spring element. From the analysis, vertical eccentricity does not give significant effect to beam stiffness and it can be neglected. The pour stop provides stiffness of 25000kN/m at the outer support. Beam deflection is independent with column deflection when column width is three times bigger than beam depth.

ABSTRAK

Rasuk bertindak balas terhadap pembebanan melalui lenturan. Oleh itu, kekukuhan lenturan rasuk boleh diwakili oleh pesongan. Secara toeri, kekukuhan rasuk dipengaruhi oleh panjang rentang rasuk, modulus elastik, momen sifat tekun dan jenis penyokong. Di dalam analisis, rasuk dianggap disokong secara sokong mudah atau sokong tegar. Bagaimanapun, terdapat beberapa faktor yang mempengaruhi kekukuhan rasuk yang tidak termasuk di dalam persamaan teori berdasarkan kes-kes sebenar dan eksperimen makmal. Faktor seperti kesipian antara paksi neutral rasuk dan penyokong (kesipian tegak), kekukuhan acuan hujung rasuk pada papak komposit, dan saiz tiang di analysis dalam kajian ini. Kesan-kesan ini di kaji dengan menggunakan tegasan satah unsur terhingga. Acuan hujung di model dengan menggunakan unsur spring. Daripada analisis unsur terhingga, didapati bahawa kesipian menegak tidak memberi impak yang signifikan terhadap kekukuhan rasuk dan ianya boleh diabaikan. Acuan hujung mempunyai nilai kekukuhan sebanyak 25000kN/m pada bahagian luar penyokong papak komposit. Pesongan rasuk tidak dipengaruhi oleh pesongan tiang apabila lebar tiang bersamaan tiga kali kedalaman rasuk.

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A_s - Steel Deck Cross Section Area
b - Beam Width
d - Steel Deck Depth
d_d - Distance from Top Slab to Centre of Steel Deck
E - Elasticity Modulus
E_c - Elasticity Modulus of Concrete
E_s - Elasticity Modulus of Steel Deck
I - Moment of Inertia
I_c - Equivalent Moment of Inertia of Concrete
I_s - Moment of Inertia of Steel Deck
L - Span Length
L_s - Shear Length
M - Moment
n - (E_s/E_c)
P - Total Load (kN)
Y_{cc} - Composite Slab Neutral Axis (measured from top of slab)

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CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 Background of the research

Beam is a main element in structural system. It is horizontal member that carries load through bending (flexure) action. Therefore, beam will deflect when it is loaded. Beam transfers the loading from slab to columns walls or girders. Generally, beam carry gravitational loads but can also be used to carry horizontal loads (i.e. loads due to a gust of wind or an earthquake).

Beams are characterized by their profile (shape of their cross section) their length and their material. In contemporary construction, beams are typically made of steel, reinforced concrete or wood. One of the most common types of steel beam is the I-beam or wide flange beam, commonly used in steel- frame buildings and bridges.

Internally, beams experience both compressive and tensile stress as a result of the loads applied. Under gravity loads, the top of the beam is under compression while the bottom of the beam is under tension, having the middle layer of the beam relatively stress-free.

Beam will deflect when it is loaded. Deflection is an important issue to the beam. Large deflection could lead to beam failure (Ahmad, 1999). There are several methods that can be used for beam analysis. The methods include Double Integration Method, MacCaulay Method, Moment Area Method, Virtual Work Method, Super Imposed Method, Coupled Beam Method, Energy Method and Castigliano Theorem (Ishak and Sulaiman, 1999). These methods can be considered as analytical solution. In analytical solution, it is assumed that beam supports were located at the beam neutral axis. On the effect of wide support, there are several composite slab experimental tests that use pour stop or end stop at the edge of the slab or beam. One example of this condition was obtained from Abdullah, R (2004). The pour stop at the outer side of the support may provide some stiffness to bending. While in fixed end condition, beam is rigidly connected to supports such as columns and therefore its stiffness increases.

1.1.1 Beam Support

Generally, there are three types of beam support that are idealized in design and analysis which are roller, pin and fixed.

i) Roller

- Roller provides resistance in one direction only. Figure 1.1 shows roller connection.

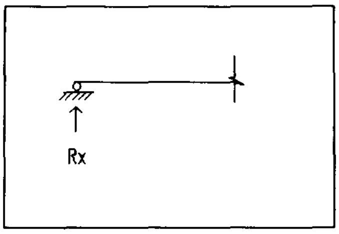

Figure 1.1: Roller Support

ii) Pin

- Pin joint will prevent beam to move in *y* direction and *x* direction, but allow beam to rotate. Therefore, no moment induce in this connection.

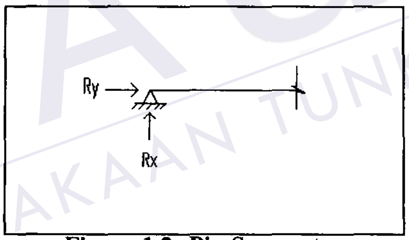

Figure 1.2: Pin Support

iii) Fixed end

- Fixed end provide resistance in both x and y direction and rotation and therefore able to persist moment.

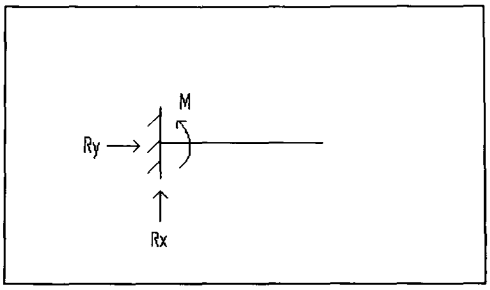

Figure 1.3: Fixed End Support

1.2 Statement of Problem

Traditionally, analytical methods assumed beams to be supported at their neutral axes. In these methods, eccentricity between beam support and beam neutral axis is neglected. However, in most bending tests, beam specimens are supported at the bottom face. This produces a vertical eccentricity between beam support and beam neutral axis. Beams are also rested on wide support as oppose to point supports Pour stops were introduced at the outer side of support in most of composite slab test. For monolithically joint beam, column size effect beam stiffness. What are the effects of the eccentricity, support width and column size to beam stiffness?

1.2 Objectives

The objectives of this project are

i) To determine the effect of eccentricity between beam support and neutral axis to beam stiffness.

ii) To determine the effect of wide support as oppose to point support.

iii) To determine the effect of column size to beam stiffness.

1.4 Scope of Work

The scope of the work carried out in this study is limited to:

i) Linear stress analysis of hypothetical beams

ii) The models are 2-D Finite Element in plane stress condition, using linear elastic materials

iii) Beam and column materials were made from concrete unless stated.

iv) Analysis are performed to examine

  - The effect of vertical eccentricity at support.
  - The effect of restraining the beam, ends at supports on the beam stiffness.
  - The effect of column beam size to stiffness.

CHAPTER 2

CHAPTER 2

LITERATURE REVIEW

2.1 Deflection Analysis

A beam will deflect when it is loaded. The deflection can be calculated using several methods such as Double Integration Method, MacCaulay Method, Moment Area Method, Virtual Work Method, Super Imposed Method, Coupled Beam Method, Energy Method and Castigliano Theorem.

2.1.1 Double Integration Method.

Beam deflects in curve shape. Therefore, deflection at any point along the beam can be calculated when the curve equation determined. To obtain the curve equation, a beam as illustrated in Figure 2.1 was considered.

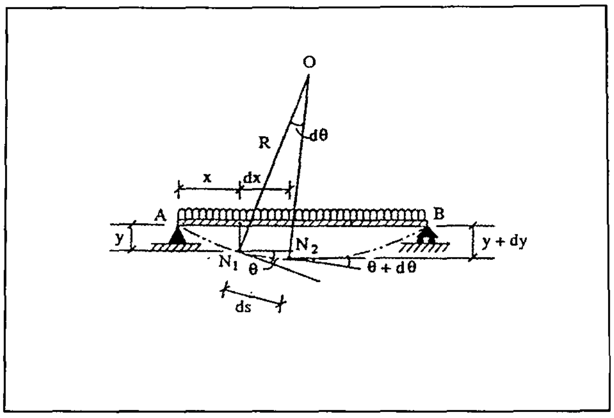

Figure 2.1: Beam Deflection (Ahmad, 1999)

N_1 and N_2 with horizontal distance *dx* at any point of the deflection were identified. With point A as reference, the dimensions of N_1 and N_2 are *x* and *x+dx* respectively. Each of N_1 and N_2 are subjected to vertical displacement of *Y* and *Y+dy* respectively and *? and ?+d?* angle of slope respectively. Distance of N_1 and N_2 in curve manner were assumed as *ds* . Therefore,

$$ds = R\,d\,?$$

$$d? = \frac{1}{R} \qquad (1)$$

dx is small, therefore

$$\tan ?\ \tilde{}\ \ ? = \frac{dy}{dx} \qquad (2)$$

? were integrated to the function of *x*

$$\frac{d\,?}{dx} = \frac{d^2y}{dx^2} \qquad (3)$$

In actual case, the deflection and slope are too small. So, the curve can be assumed as linear and

$$\cos ? = \frac{dx}{dx} \qquad (4)$$

cos ? = 1 due to small slope, ?

Therefore, equation 1 can be rewritten as

$$\frac{d\,?}{dx} = \frac{1}{R} = \frac{d^2y}{dx^2} \qquad (5)$$

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