THE PERFORMANCE OF SLIM CONCRETE BEAM USING NYLON MESH CONFINEMENT

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ABSTRACT

Confinement has become significant way to improve ductility of concrete structure member which is very important in concrete earthquake resitant design. When a requirement of ductile-resistant concrete structure member is provided by beam concrete, then its performance should be supported by strength effort in reducing the hazard of earthquake, in example, by introducing the nylon mesh confinement. For slim beams, it is important to determine how the beam behave during the loading history. This research investigates the performance of slim beam using nylon mesh confinement. The research is conducted experimentally by some specimens of slim beams which are unconfined and confined by nylon mesh. All specimens have: f'_c design = 40 MPa, b = 10 cm, d = 20 cm, a = 100 cm, L = 300 cm, and slenderness ratio 5. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh. The specimens are tested by third point flexural beam test by computerized UTM and data logger of strain gauges.The research meets conclusions: (1) The confined slim beams perform higher maximum load with same displacement of 70 mm; (2) The confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not; (3) The curvature of ductility ratio and curvature of slim beams of confined slim beams are about the same; (4) The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam; (5) The confined slim beams perform higher ductility compared to unconfined beam; and (6) The nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member.

Keywords: *performance, slim, beam, nylon, mesh, confinement*

INTRODUCTION

Confinement has become significant way to improve ductility of concrete structure member which is very important in concrete earthquake resitant design. When a requirement of ductile-resistant concrete structure member is provided by beam concrete, then its performance should be supported by strength effort in reducing the hazard of earthquake, in example, by introducing the nylon mesh confinement. For slim beam, which has slenderness ratio of and more than 5, it is important to determine how the beam behave during the loading history.

Park and Paulay (1975) explain that the mechanism of confining effect is not so simple. When compressive stress achieved in lower value, transversal reinforcement is stressed, but it is lightly, then the reinforcement will not affect the concrete area. If only ultimate stress achieved, the transversal strain of concrete is increase, and crack propagation will be generated. Because of the phenomenon, concrete is expanding and then will compress the transversal reinforcement. In case compresive area confined, then the ductility of beam will be improved.

Concrete beam should be designed in ductile way to assure its earthquake resistance. When slim beams applied to the structure, its failure mechanism will become very important consideration. According to Nawy (1996), slim beams are categorized by slenderness of ratio of shear span, a, and effective depth, d, of beam. Slim beams have slenderness of more than 5, while moderate slim beams have slenderness of 2.5-5, and deep beams have slenderness of less than 1. Generally, the performance of slim beams are subjected to shear, but this paper want to discuss its flexural performance as well while nylon mesh confinement applied.

Some previous researches emphazise the advantage of confinement to improve beam ductility such as Wu and Sun (2005) use thin CFRC (*continuous fiber reinforced cement*) and CFRC (*continuous fiber reinforced polymer*) sheets for structural retrofit as external wrap to achieve maximum load; Rafeeqi, Lodi, and Wadalawala (2005) upgrade and strengthen beams with ferrocement strips and wraps with one or two layers of wire mesh; Delalibera and Giongos (2008) apply additional transversal reinforcement of stirrups in compression area. Nylon mesh confinement has been applied in concrete beams by Setyanegara and Sagitha (2008), Lelono and Widi (2009), Susilorini, et. al. (2009), Susilorini (2009a-d). Those researches have shown significant ductility improvement of beam. It can be understood because nylon fiber that is applied into cementitious matrix has advantages such as great value of tension strength and elongation also unique characteristic of 'yield point elongation' (Susilorini, 2007; 2008; 2009e,f).

Analitically, two parameters (Park and Paulay, 1975) discussed in this paper can be explained by equations (1)-(3) as follow.

The rotation of beam can be expressed by

$$\theta = \int_A^B \frac{M}{EI} dx \qquad \text{.........(1}$$

Where θ = rotation, M = internal moment, E = material's modulus of elasticity, I = beam's moment of inertia computed about the neutral axis.

The curvature of ductility is

$$\kappa = \frac{1}{\rho} = \frac{M}{EI} \qquad \text{.........(2}$$

Where μ_θ = curvature ductility ratio, μ_u = curvature at ultimit stage, and μ_y = curvature at yield stage.

It is important to learn behaviour of confined slim beams, hence, this research investigates the performance of slim beam using nylon mesh confinement.

METHODS

This research is conducted experimentally by some specimens of slim beams which are unconfined and confined by nylon mesh. All specimens have: f'_c design = 40 MPa, b (width) = 10 cm, d (depth) = 20 cm, a (shear span) = 100 cm, L (span) = 300 cm. The specimens consists of one unconfined slim beam and 3 confined slim beams with slenderness ratio (a/d) of 5. The confinement made of nylon mesh with mesh spacing of 5 cm. Nylon mesh consists of nylon fibers with diameter of 1.1 mm which are assembled to be mesh which covers the steel bar (Figure 1). The specimens are tested by third point flexural beam test by computerized UTM and data logger of strain gauges (Figure 2).

Figure 1. Nylon mesh with mesh spacing of 5 cm which cover the steel bar (Susilorini, 2009b)

Figure 2. Experimental set-up with computerized UTM and data logger of strain gauges (Susilorini, 2009b)

RESULTS AND DISCUSSION

Experimental results show that confined slim beams perform higher maximum load, about 13000-14000 N, compared to unconfined ones, about 12000 N, with same displacement of 70 mm (Figure 3). The load-displacement curve described by Figure 3 also shows that the confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not.

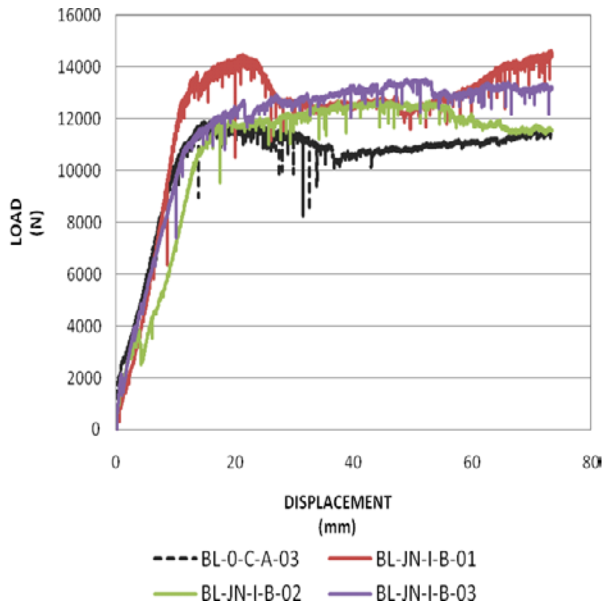


Figure 3. Load-displacement relation of beam specimens (Modified from Susilorini, 2009)

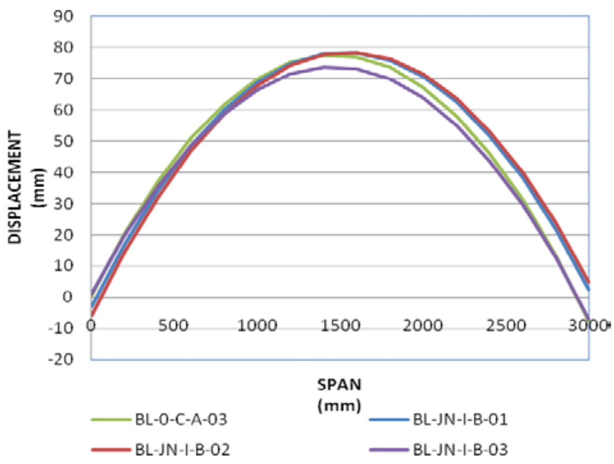


Figure 4. Curvature of beam specimens at ultimate load (Modified from Susilorini, 2009)

However, as explained by Table 1, the curvature of ductility ratio of confined slim beams are about the same, it ranged about 1.16-1.29 while for the unconfined one is 1.2. The curvature of slim beams are also about the same, 0.00000080-0.00000096. It is clear that the most important performance distinctions between the unconfined and confined slim beams are higher ultimitate load of the confined slim beams and strain-hardening character in ultimate stage of load-displacement curve of confined slim beams.

Table 1. The value of curvature of beam specimens at ultimate load

NO	SPECIMEN CODE	CURVATURE DUCTILITY RATIO	CURVATURE OF BEAM	ROTATION (rad)
		μ_ϕ	κ	θ
1	BL-0-C-A-03	1.200	0.0000008091	0.105
2	BL-JN-I-B-01	1.157	0.0000009675	0.107
3	BL-JN-I-B-02	1.292	0.0000008765	0.109
4	BL-JN-I-B-03	1.293	0.0000009068	0.099

Failure mechanism of slim beams can be observed by crack pattern of slim beams at ultimate stage of displacement of 70 mm (Figure 7). The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam (Figure 5, 7, and Table 1).

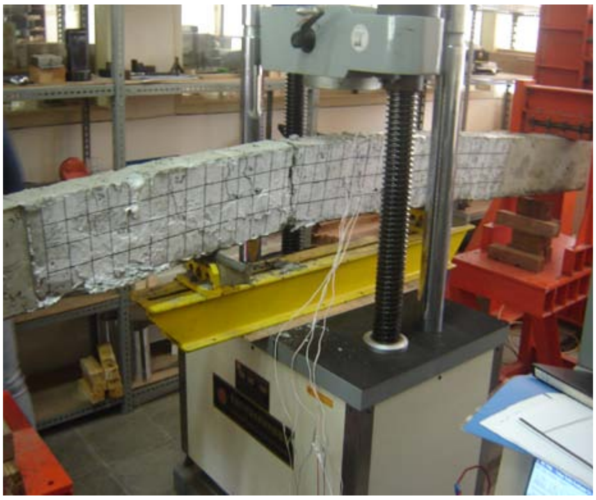
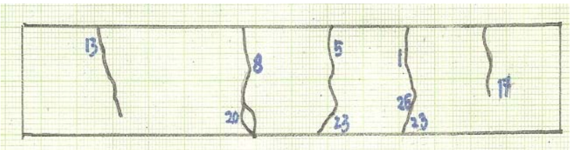


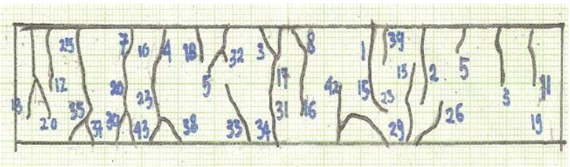
Figure 5. Curvature of beam specimens during loading history (Susilorini, 2009b)

While the bigger load resisted by the confined slim beams, then cracks start to propagate. Hence, the confined slim beams performs bigger curvature of beams because more cracks grow (Figure 6) while the beams resist load increasing. Therefore, the confined slim beams perform higher ductility compared to unconfined beam. This research proves that the nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member.

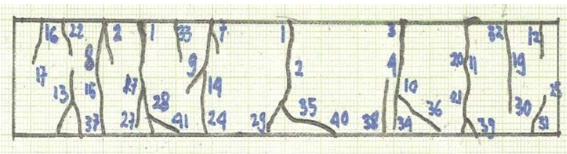
Figure 6. Crack at middle span of beam specimens at ultimate stage (Susilorini, 2009b)



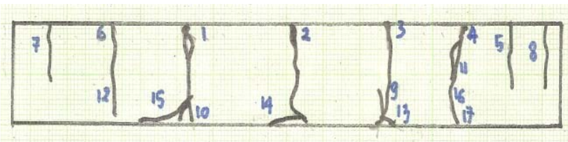
(a)



(b)



(c)



(d)

Figure 7. Crack patern of beam specimens at ultimate load (Susilorini, 2009b)
(a) BL-0-C-A-03
(b) BL-JN-I-B-01
(c) BL-JN-I-B-02
(d) BL-JN-I-B-03

CONCLUSIONS

This paper meet conclusions:

1. The confined slim beams perform higher maximum load with same displacement of 70 mm
2. The confined slim beams perform ductile behaviour with strain-hardening character in ultimate stage while the unconfined beam does not.
3. The curvature of ductility ratio and curvature of slim beams of confined slim beams are about the same
4. The unconfined slim beam shows less cracks compared to confined one while it achieves lower ultimate load and perform lower value of curvature of beam
5. The confined slim beams perform higher ductility compared to unconfined beam
6. The nylon mesh significantly improve the ductility of slim beam and perform good performance of earthquake resistant concrete structure member

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