DUCTILITY IMPROVEMENT OF DEEP BEAM BY NYLON MESH CONFINEMENT

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ABSTRACT

Indonesia is earthquake prone area which needs awareness of disaster reducing efforts. One effort to provide earthquake resistant building is to serve ductile concrete structure member such as beam. For recent time, the confinement has become important way in improving ductility of concrete beam. This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some specimens confined by expanded metal sheet. The research conducted experimentally by some deep beam specimens with specification: f'_c design = 30 MPa, b = 10 cm, d = 20 cm, a = 20 cm, and L = 60 cm; some confined by nylon mesh and some confined by expanded metal sheet. 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. The research meets conclusions: (1) The deep beams using nylon mesh confinement improves utlimate load significantly, up to 150%, compared to unconfined one while its ultimate load is 20% higher than the ones using expanded metal sheet; (2) The modulus of rupture of deep beams using nylon mesh confinement is about 15% higher compared to beams using expanded metal sheet confinement and 230% higher than unconfined deep beams, and (3) It is proved that nylon mesh confinement can improve ductility of deep beam significantly, hence the deep beams confined by nylon mesh perform as earthquake resistant concrete structure member.

Keywords: *ductility, deep, beam, nylon mesh, confinement*

INTRODUCTION

Indonesia is earthquake prone area which needs awareness of disaster reducing efforts. One effort to provide earthquake resistant building is to serve ductile concrete structure member such as beam. For recent time, the confinement has become important way in improving ductility of concrete beam.

The importance of confinement application for beam has been delivered by previous researches in various materials and design (CFRC, *continuous fiber reinforced cement*; CFRC, *continuous fiber reinforced polymer*; fer-rocement strips; wire mesh; steel stirrup) in examples Wu and Sun (2005); Rafeeqi, Lodi, and Wadalawala (2005); Delalibera and Giongos. Previous researches on nylon mesh confinement have been established by Setyanegara and Sagitha (2008), Lelono and Widi (2009), Susilorini, et. al. (2009), Susilorini (2009a-d). As emphasized by Susilorini (2007; 2008; 2009a-d), nylon fiber has advantages such as great value of tension strength and elongation also unique characteristic of 'yield point elongation', and stable crack width.

Deep beam is a term of beam which has slenderness ratio (a/d) of less than 1 (Nawy, 1996). Deep beams generally used in tall building that is supported by individual column; also used as transfer girders in long span structures (Shah and Mishra, 2004). The ductility performance of deep beams is necessary for good earthquake resistant design. Hence, some parameters such as displacement, ultimate load, and modulus of rupture, are needed to define the ductility of deep beams.

Modulus of rupture is defined as theoritical maximum tensile stress at the bottom fiber of beam (Neville, 1999) which can be expressed by

$$R = \frac{PL}{bd^2} \qquad \text{............(1}$$

Where R = modulus of rupture, P = load, L = beam span, d = depth.

This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some specimens confined by expanded metal sheet.

METHODS

The research conducted experimentally by some deep beam specimens with specification: f'_c design = 30 MPa, b (width) = 10 cm, d (depth) = 20 cm, a (shear span) = 20 cm, and L (span) = 60 cm; some confined by nylon mesh and some confined by expanded metal sheet. 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 cover the steel bars. There is no transversal reinforcement. The specimens consist of one unconfined deep beam, 3 deep beams using nylon mesh confinement (Figure 1), and 3 deep beams using expanded metal sheet confinement (Figure 2).

The specimens are tested by third point flexural beam test as described by Figure 3. The load and displacement measured by dial gauges. A hydraulic jack used to load the specimens.

Figure 1. The placement of nylon mesh confinement for deep beams which cover the steel bar (Lelono and Widi, 2009; Susilorini, 2009a,b)

Figure 2. The placement of expanded metal sheet confinement for deep beams which cover the steel bar (Lelono and Widi, 2009; Susilorini, 2009a,b)

Figure 3. Experimental set-up with dial gauges and hydraulic jack loading equipment (Lelono and Widi, 2009; Susilorini, 2009a,b)

This paper wants to deliver how the nylon mesh confinement can effectively improve the ductility improvement of deep beam. As comparison, it is also conducted some deep beam specimens confined by expanded metal sheet.

RESULTS AND DISCUSSION

Experimental result of Figure 4 shows that confined deep beams by nylon mesh achieve maximum load about 2100-2400 N and displacement about 10-12 mm, and modulus of rupture 31.5-36 MPa; while the confined deep beams by expanded metal sheet achieve maximum load about 1800-2200 N and displacement about 14-16 mm. The unconfined beam can only achieves load of 1000 N at displacement of 8 mm.

Firstly, the deep beams using nylon mesh confinement improves utlimate load significantly, up to 150%, compared to unconfined one. The ultimate load of deep beams using nylon mesh confinement is 20% higher than the ones using expanded metal sheet. Secondly, the load-displacement curve of confined deep beams by nylon mesh has shown more ductile behaviour that there is smooth increasing of load at stage yield and ultimate while the confined deep beams by expanded metal sheet has 'jump' increasing load from stage yield to stage ultimate.

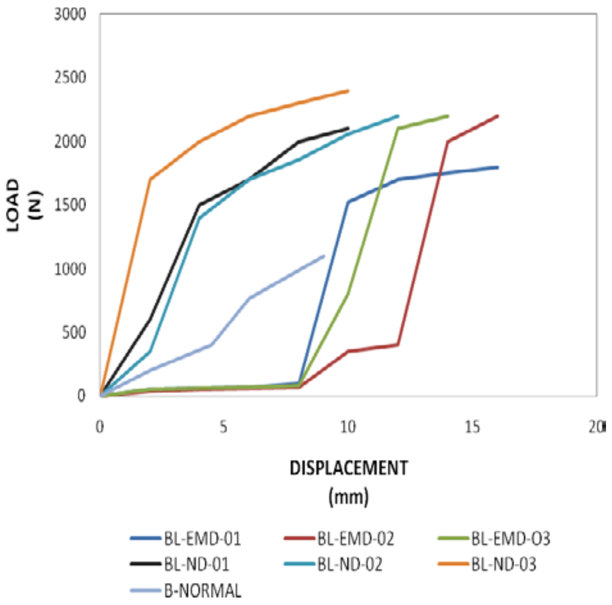

Figure 4. Load-displacement relation of beam specimens (Modified from Lelono and Widi, 2009)

In other words, nylon mesh confinement maintain load increasing at yield stage as well as ultimate stage. On the opposite, the expanded metal sheet confinement cannot keep the load at elastic stage as high as nylon mesh confinement. After first crack, the load jumps up and suddenly after the ultimate load achieve it is getting failure immediately. Even though the displacement of deep beams using nylon mesh confinement is lower, it still keep ductile behaviour better than deep beams using expanded metal sheet confinement.

Figure 5 shows that the modulus of rupture of deep beams using nylon mesh confinement ranged about 27-33 MPa. The values are about 15% higher compared to the deep beams using expanded metal sheet confinement and 230% higher than unconfined deep beams. It means, the nylon mesh confinement effectively improve maximum tensile stress at the bottom fiber of deep beam, much better than.

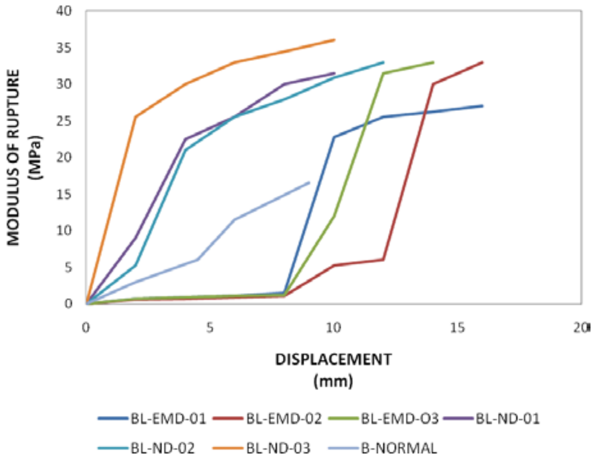

Figure 5. Modulus of rupture-displacement relation of beam specimens (Modified from Lelono and Widi, 2009)

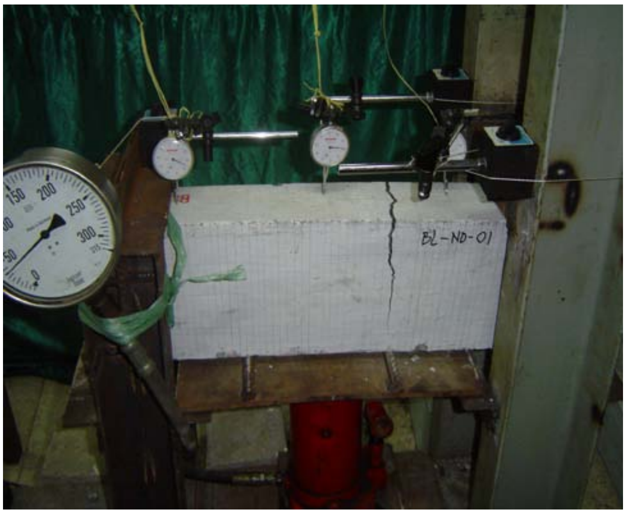

Figure 6. Crakced deep beam using nylon mesh confinement (Lelono and Widi, 2009)

Figure 7. Failure of deep beam using expanded metal sheet confinement (Lelono and Widi, 2009)

The failure of deep beam specimens can be explained through observation as follow. At failure stage, the deep beams specimen using nylon mesh confinement are not separated into two partst. Figure 6 shows that the nylon mesh keep the deep beams engaged by small width of crack in the middle of the beam. On the contrary, at the failure stage, the deep beams using expanded metal sheet confinement are broken into two parts, as described by Figure 7. It can be said that the broken deep beams have brittloe confinement, it is expanded metal sheet confinement.

CONCLUSIONS

This paper meet conclusions:

1. The deep beams using nylon mesh confinement improves utlimate load significantly, up to 150%, compared to unconfined one while its ultimate load is 20% higher than the ones using expanded metal sheet
2. The modulus of rupture of deep beams using nylon mesh confinement is about 15% higher compared to beams using expanded metal sheet confinement and 230% higher than unconfined deep beams
3. It is proved that nylon mesh confinement can improve ductility of deep beam significantly, hence the deep beams confined by nylon mesh perform as earthquake resistant concrete structure member

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