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The effect of wire mesh confinement to compressive strength and deformability of cylindrical concrete

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Abstract
The research is intended to evaluate the effectivity of of wire mesh confinement on cylindrical concrete. Six of specimens that consist of a standard cylinder with one layer, two layers, and three layers of wire mesh. The result shows that wire mesh confinement can improve the compressive strength and greater deformation before repture. Compressive strength and deformation have also improved during an increasing of number wire mesh layer or an increasing of confinement volumetric. The maximum stress improvement range is about 1.004 – 1.42 times or 0.397% - 41.98% of strength compared to cylindrical control with no wire mesh.

Keywords: wire, mesh, confinemen, cylindrical, concrete, compressive, strength

1. Introduction
Confinement in reinforced concrete is apart action that works to tighten longitudinal reinforcement on beam, column, shearwall, and joint. A number of research show that confinement, has an important function to prevent a crack and initial shear failure, to improve a compressive strength and flexure strength and also to increate elements of ductility. Since initiated by Richart [1], study of behaviour and an efectivity of confinement have done by researchers. More or less 80 years, study of confinement on reinforced concrete structural components have developed significantly either on configuration, sizing or variations. Wire mesh is made from a flexible steel, easy to form as to square, hexagonal or circle stirrups. A behavior of wire mesh as confinement has not many know yet because the study is still limited. This research will examine the effectiveness of wire mesh as a cylindrical confinement material.

2. Materials and Methods
2.1 Materials
Material components consist of a main material of conventional concrete such as gravel, sand, cement, and water as well as wire mesh as confinement. Confinement is produced from Galvanized welded wire mesh, which is made in China, having diameter of 1.67 mm and grid space of 40 mm. Yield strength of wire mesh is equal to 466 MPa. The use of ypical wire mesh is shown in Fig 1.

Fig 1: Type of wire mesh

2.2 Methods
a. Mix design of specimen
Cylindrical concrete is designed at 20 MPa with composition of concrete components can be seen in Table 1.

Table 1: Mix Design of Specimens

Specimen	Mix Weight (kg)				Fas
	Cement	Sand	Gravel	Water	
CC/CW	395	500	1168	225	0.57

b. Test Materials
Specimens consist of two cylinders with no confinement as a control (CC) and with wire mesh cylinder (CW). Confinement cylinder is prepared with 3 variations, namely one layer confinement (CW1), two layers (CW2), and 3 layers (CW3). Each variant has two specimens, thus there are six units of total specimens. There is no space between layers, and no space between wire mesh and outer cylinder is 5 mm. End of wire mesh is 50 mm and is tightened by bendrat.

Fig 2: Wire Mesh In The Mould Cylinder

c. Test Process
The cylinder surface can be leveled using sulfur so that when loading it is distributed on surface of the cylinder. Two units of Linier Variable Differential Transducer (LVDT) with 50 mm of capacity are installed side by side of 180 which is

connected with portable data logger as recorder of shortness for the specimens during experiment. The shortness of specimens is a mean of two LVDT numbers. Test material might include Universal Testing Machine (UTM) that has two tons of capacity as shown in Fig. 3. Direction of loading is upwards and the results can be read on dial of machine.

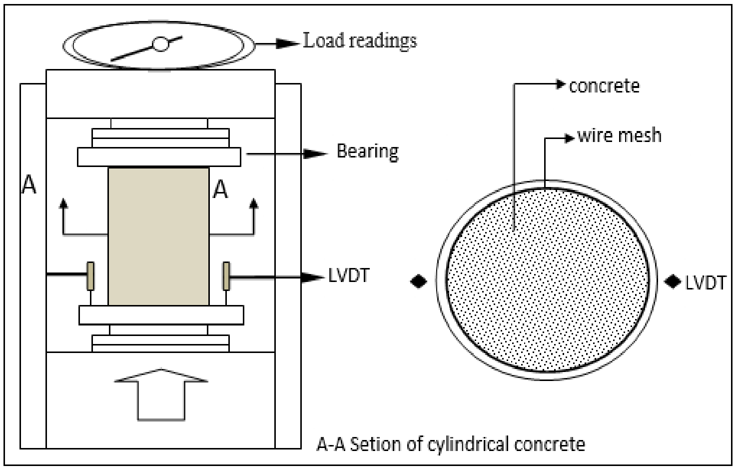


Fig 3: Setting Up the Compression and Section

3. Results and Discussion

a. Crack patterns and collapse mode of cylinder with wire mesh confinement

Crack in all specimens occures before peak load and spalling happens after peak load. All specimens reaches ultimate strength before wire mesh is broken. The types of cylinder collapse appear at the one layer (CW1.2), at two layers (CW2.2), and at three layers of wire mesh (CW3.2) as shown in Fig. 4.

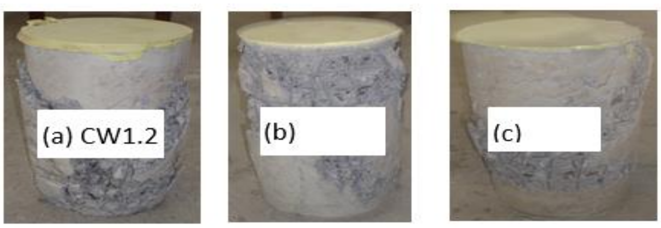


Fig 4: Crack Mode and Collapse of Confinement Wire Mesh

b. Stress-strain relation of wire mesh confinement cylinder

A peak stress of wire mesh cylinder are improved by increasing a number of wire mesh layer (Fig. 5) and the value and ratio of peak stress of cylinder can be seen in Table 2 and Fig. 5 which reach 1.004 –1.42 times or 0.397%-41.98% of strength compared to cylinder having no wire mesh. Improvement of stress number is caused by an increase of volumetric ratio of confinement.

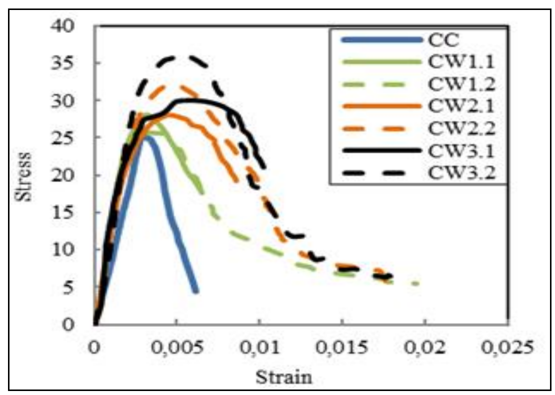
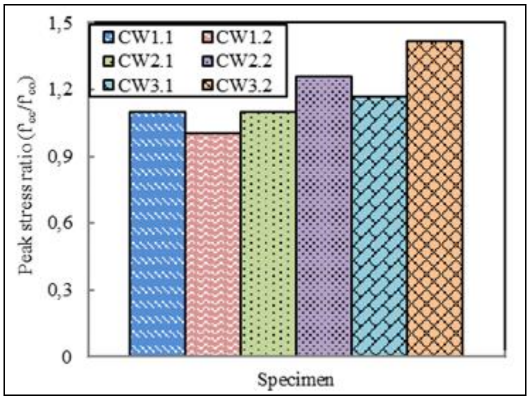


Fig 5: Graph of Wire Mesh Layer

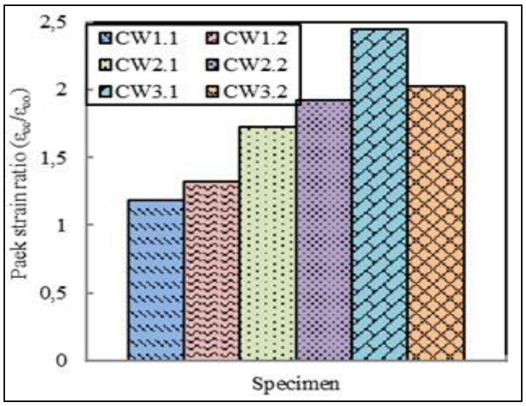
Value and ratio of peak strain of confinement cylinder each about 0.003-0.007 and 1.299–2.688 times of cylinder without confinement.

Table 2: Test Results of Compressive Cylinder

Specimen	Peak Stress f_{co} or f'_{cc} (MPa)	Peak Strain ε_{cc}	Ult. Strain ε_{cu}	Peak Stress ratio f'_{cc}/f_{co}	Peak strain Ratio $\varepsilon_{cc}/\varepsilon_{co}$	Ult. Strain ratio $\varepsilon_{cu}/\varepsilon_{co}$
CC	25,592	0.002	0.004	1.000	1.000	
CW1.1	28.180	0.003	0.009	1.101	1.299	2.644
CW1.2	25.693	0.004	0.008	1.004	1.452	2.166
CW2.1	28.106	0.005	0.008	1.098	1.894	2.089
CW2.2	32.175	0.005	0.008	1.257	2.116	2.094
CW3.1	29.956	0.007	0.005	1.171	2.688	1.404
CW3.2	36.335	0.005	0.006	1.420	2.230	1.604



(a)



(b)

Fig 6: (a) Graph of peak stress comparison and (b) graph of peak strain of confinement cylinder with no wire mesh.

c. Ductility

Ductility refers to the ability of section, element or structure in deformating when its strength does not loose significantly. The formula for ductility factor with regard to stress concrete section can be seen in (1) below: $\mu_{80} = \varepsilon_{cu}/\varepsilon_{01}$

In which

ε_{cu} = Axial strain corresponding to a stress 0,8 f'_{cc} on the descending portion of the specimen stress-strain curve.

ε_{01} = Axial strain corresponding to the maximum concrete stress on the initial tangent (E_i) as shown in Fig. 7.

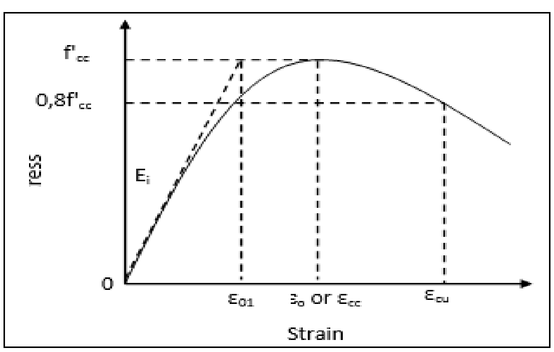


Fig 7: Parameters of stress-strain curve and definition of ductility factor

The results of ductility factor as shown in Fig. 8 indicates that ductility factor of wire mesh confined cylinder is improved by increasing the number of wire mesh layer. A higher ductility factor comes from cylinder with three layer of wire mesh and it is noted 3 times of ductility factor without wire mesh confinement. Ductility factor of cylinder is about 2.17-3.83 or 82.186%-208.163% of ductility without wire mesh. Ultimate strain ratio against peak strain ($\varepsilon_{cu}/\varepsilon_{cc}$) of cylinder with one layer, with two layers, and with three layers of wire mesh confinement are relatively not different.

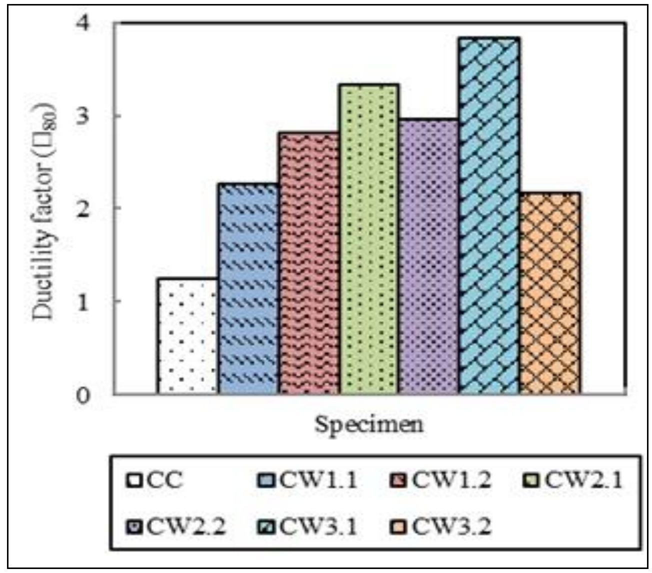


Fig 8: Ductility factor with and without wire mesh confinement

d. Peak stress–strain model from several researchers

Basically, the characteristics of confined concrete lies on the constitutive model of stress–strain peak and stress–strain curve. The stress peak modeling results the confinement that is initiated by Richart *et al.* (see [1] who argues that modeling confinement looks like fluid pressure or spiral reinforcement. Recently, confinement models, either inner confinement or outer confinement are more developed with various approaching model.

The results in relation to peak stress and strain ratio of confined cylinder using Mender *et al.* [2] or MM, Saatcioglu and Razvi models [3] or MSR, Legeron and Paultre models [4] or MLP, EL-Dash and Ahmad or MELDA, [5] and Assa *et al.* Model [6] or MANW are shown in Table 3 and 4.

Table 3: Peak stress ratio from several model of experiment

Specimen	MM/ Test	MSR/ Test	MLP/ Test	MELDA/ Test	MANW/ Test
CW1.1	0.941	1.011	0.940	0.936	0.952
CW1.2	1.032	1.109	1.031	1.026	1.044
CW2.1	1.039	1.095	0.995	0.989	0.999
CW2.2	0.908	0.957	0.869	0.864	0.873
CW3.1	1.032	1.100	0.960	0.954	0.980
CW3.2	0.851	0.907	0.791	0.786	0.808

Table 4: Peak strain ratio from several model of experiment

Specimen	MM/ Test	MSR/ Test	MLP/ Test	MELDA/ Test	MANW/ Test
CW1.1	0.910	0.906	0.789	0.783	1.006
CW1.2	0.814	0.810	0.706	0.701	0.900
CW2.1	0.900	0.676	0.597	0.564	0.855
CW2.2	0.806	0.605	0.535	0.505	0.766
CW3.1	0.760	0.510	0.452	0.411	0.723
CW3.2	0.916	0.614	0.545	0.495	0.871

Peak stress ratio from several models of experiment as seen in Table 3 indicates that MM and MSR models results in its predicted value that is close to the experiment. MLP, MELDA and MANW models shows a peak stress ratio smaller than peak stress of experiment test. Comparison results of peak strain ratio in Table 4 proves that MM model indicates a peak strain which is predicted to be smaller and closer to peak strain in the experiment of confinement of one, two, and three layers of wire mesh. Other models are predicted to be smaller than peak strain of experiment test.

4. Conclusions

It can be concluded that

1. Wire mesh confinement can increase a compressive strength of cylinder and the deformating is greater before it collapses.
2. Compressive strength and ductility factor also increase when the number of layers of wire mesh shows an increase.
3. Mander *et al*. (1998) [2] and Saatcioglu and Razvi (1992) [3] models contribute a peak stress that is close to experiment test.
4. Wire mesh is potentially used for confinement.

5. Acknowledgment

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