# 圧縮状態でのセメント複合材パネルのヤング率
# Young’s Modulus of Cement Composite Panels Under Compression

○エムディ。ザカリア ホセイン*, 井上　宗治*
○Md. Zakaria Hossain*, Inoue Sohji*

**I. Introduction**: Wire mesh cement composite has become a very common construction material in the engineering of today because of their high strength to weight ratio. Among many types of wire meshes, the chicken wire mesh and woven square wire meshes are widely used in modern cement composite structures owing to their ease of availability in the local market. In order to improve the quality of this material and to optimize the material usage, it is utmost necessary to understand the mechanical behavior of this kind of composite material. In this investigation, an experimental study on the basic mechanical property such as Young's modulus of cement composite panels reinforced with chicken wire mesh and woven square wire mesh under uniaxial compression is carried out. Cement composite elements of sizes 200mmX100mmX20mm and 200mmX140mmX30mm have been cast and tested after 7 days of curing. Results of the Young’s modulus of the individual and group specimens with variation of number of mesh layers as well as volume fraction of reinforcement are presented. In view of their effective and suitable applications for structural design, simple prediction equations are also proposed in this paper.

**II. Materials and methods:** The specimens were made in the wooden moulds with their top open. Ordinary Portland cement and river sand passing through No.8 (2.38mm) seive, having a fineness modulus of 2.33 were used for casting. For all the specimens, the W/C and C/S ratios both were 0.5 by weight. In each casting, three specimens along with two elements of plain mortar of the same size and thickness were cast and tested to determine the compressive strength, modulus of elasticity and poison's ratio of the plain mortar. The ordinary mesh obtained from the market was cut to obtain the requisite number of layers of desired size and orientation. The diameter of wire was 0.8mm for chicken mesh and 1.2mm for square mesh. All the elements were tested with a 1962kN capacity hydraulic avery type testing machine. The readings were taken initially at intervals of 9.81 kN and subsequently at 4.905 kN. The displacements of elements end compression were measured with dial gages having a least count of 0.01 mm.

**III. Identifying code:** The specimens were assigned to an identified code consisting of numbers and symbols such as S2UL30, H2UL20 etc. Here, 2 stands for 2 layers of mesh, L stands for arrangement of mesh in longitudinal direction, U stands for uniform distribution of mesh layers, S stands for square mesh and H stands for hexagonal (chicken) mesh . The numerical value (20 or 30) at the end of the code indicates the thickness of the cement composite elements in mm.

**Table 1. Young’s Modulus of Cement Composite**

| Specimens | Volume fraction of mesh | $E_{comp.}$ kN/mm$^2$ | Average $E_{comp.}$ |
|---|---|---|---|
| Mortar (1)<br>Mortar (2)<br>Mortar (3) | 0.00 | 10.00<br>7.142<br>5.882 | 7.6746 |
| H2UL20(1) | 0.87 | 4.16 | 4.16 |
| H3UL20(1)<br>H3UL20(2) | 1.31 | 2.42<br>6.40 | 4.41 |
| H4UL20(1)<br>H4UL20(2) | 1.75 | 3.57<br>6.25 | 4.91 |
| H5UL20(1)<br>H5UL20(2) | 2.19 | 3.12<br>6.25 | 4.68 |
| S1U30 (1)<br>S1U30 (2)<br>S1U30 (3) | 0.75 | 4.255<br>9.090<br>6.666 | 6.6703 |
| S2U30 (1)<br>S2U30 (2)<br>S2U30 (3) | 1.50 | 2.857<br>6.000<br>3.529 | 4.1286 |
| S3U30 (1)<br>S3U30 (2)<br>S3U30 (3) | 2.25 | 5.555<br>3.636<br>2.325 | 3.8386 |
| S4U30 (1)<br>S4U30 (2)<br>S4U30 (3) | 3.01 | 3.333<br>5.714<br>1.851 | 3.6326 |
| S5U30 (1)<br>S5U30 (2)<br>S5U30 (3) | 3.76 | 3.333<br>1.369<br>1.851 | 2.1843 |

**IV. Results and discussions:** Young’s modulus of cement composite reinforced with woven sqaure mesh varies with the variation of volume fraction of reinforcement as shown in Fig.1. It is ovserved from this figure that the young’s modulus of the cement composite decreases with the increase in volume fraction of reinforcement. The decrease of Young’s modulus of the cement composite is higher with the higher percentage of volume fraction of reinforcement for woven sqaure mesh composite. To be able to predict the Young’s modulus of the cement composite containing woven sqaure mesh, the linearized least square curves have been drawn and plotted in Fig.2.

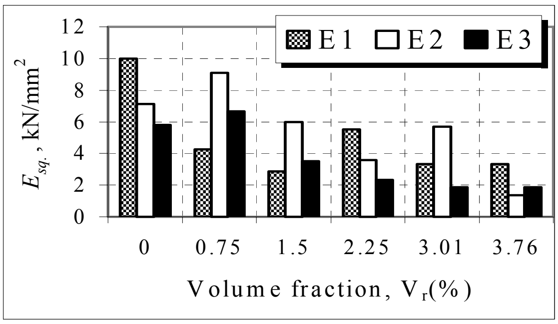


Fig.1. $E_{sq.}$ versus $V_r$ for woven square mesh

*三重大学生物資源学部, Faculty of Bioresources, Mie University; 「ワイヤメッシュ、セメント複合材、圧縮ヤング率」

The dotted linearized curves show the individual categories of the cement composite whereas the solid linearized curves is for the combined one for all the categories of the cement composite with woven square mesh. Thus, an expression for estimating the Young's modulus of cement composite containing woven square mesh can be written as

$$E_{sq.} = -1.3958V_r + 7.2968 \qquad ------ \qquad (1)$$

Here, $E_{sq.}$ is the Young's modulus of cement composite under compression in kN/mm$^2$ and $V_r$ is the volume fraction of woven square mesh reinforcement in percent.

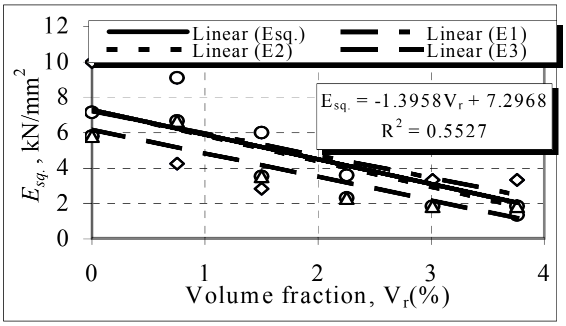


Fig.2. Linearized curves of $E_{sq}$.

Alike with the cement composite of woven square mesh, the Young's modulus of cement composite reinforced with chicken mesh varies with the variation of volume fraction of reinforcement as shown in Fig.3. It is also ovserved from this figure that the young's modulus of the cement composite decreases with the increase in volume fraction of reinforcement. Unlike with the cement composite of woven square mesh, the decrease in Young's modulus of the cement composite is lower with the higher percentage of volume fraction of reinforcement for chicken mesh composite. For determination of Young's modulus of the cement composite containing chicken mesh, the linearized least square curves have been drawn and plotted in Fig.4 .The dotted linearized curves show the individual categories of the cement composite whereas the solid linearized curves is for the combined one for all the categories of the cement composite with chicken mesh. Thus, an expression for estimating the Young's modulus of cement composite containing chicken mesh can be written as

$$E_{ch.} = -1.58V_r + 7.2699 \qquad ------ \qquad (2)$$

Here, $E_{ch.}$ is the Young's modulus of cement composite under compression in kN/mm$^2$ and $V_r$ is the volume fraction of chicken wire mesh reinforcement in percent.

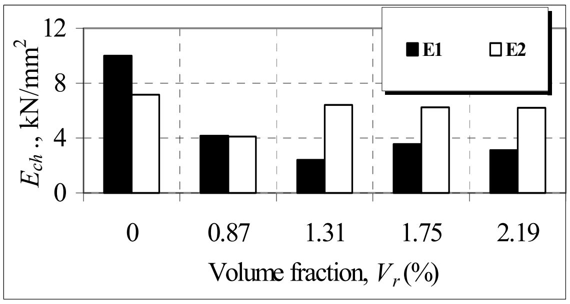


Fig.3 $E_{ch}$. versus $V_r$ for chicken mesh

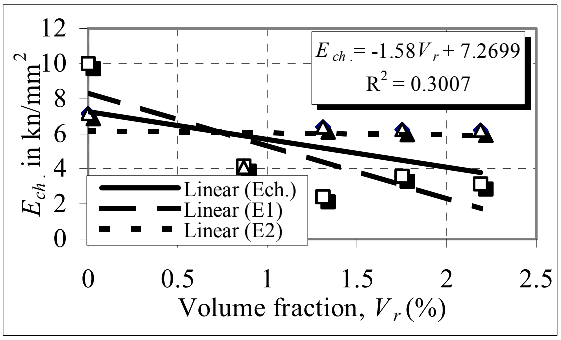


Fig.4. Linearized curves of $E_{ch}$.

In order to facilitate generalized design convension, the data plotted in Figures 1-4 are condensed in Fig.5 in terms of combined Young's modulus to the target of eliminating the effect of mesh type in the cement composite and obtained a combined linearized least square curve for the cement composite for any kind of mesh. Therefore, the following expression for combined Young's modulus of cement composite under compression is obtained

$$E_{com}. = -1.4333V_r + 7.2904 \qquad ----- \qquad (3)$$

Here, $E_{com}$ is the combined Young's modulus of cement composite under compression in kN/mm$^2$ and $V_r$ is the volume fraction of reinforcement in percent.

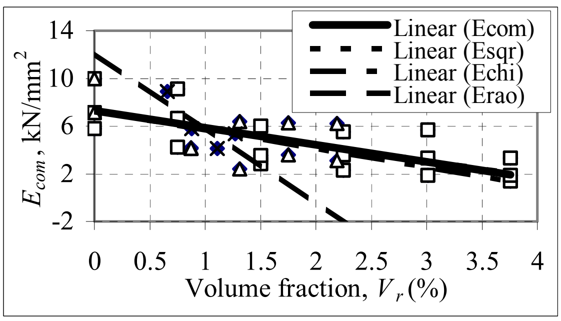


Fig.5. Combined linearized curves for $E_{com.}$

**V. Conclusions**: Scatterness in the compression test results regarding Young's moduli is a common feature for the individual specimen reinforced with same type and amount of wire mesh. There is a downswing in the average Young's moduli values for cement composite reinforced with chicken mesh and woven square mesh. The average Young's modulus of the plain mortar specimens is fairly higher than that of cement composite elements reinforced with any kind of wire mesh.


**References:** Hossain, M.Z. and Inoue, S. Compressive characteristics of cement composite panels reinforced with chicken wire mesh, Annual Conference of JSIDRE, Tottori, 2000, pp.588-589.