

# Study about dynamic modulus of linear deformations during the hardening of polymer concrete composition

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**Abstract:** In the study, experimental studies were made to obtain quantitative values for dynamic modulus of longitudinal deformations of polymer concrete composite. It will be used for structural material for bodies and hulls. A standardized test method ASTM E1876-09 was used.

**Keywords:** DYNAMIC MODULUS, NODE LINES, IMPULSE, MICROPHONE, LONGITUDINAL VIBRATION

## 1. Introduction

Dynamic loads cause dynamic deformations in the housing elements of machines and equipment, caused by mechanical oscillations with certain frequencies and amplitudes. These deformations directly affect the working accuracy of the production equipment. To increase static and dynamic stability minimization of deformations at the machine designing phase, through the correct sizing and optimization of the relevant elements has been required [1].

Global trend recently is the replacement of gray cast iron as a construction material (in part of engineering production) with polymer concrete composites. The application of polymer concrete composites in the production of bodies is particularly relevant. Usage of polymer concrete composite materials is becoming a way to solve difficult and multifaceted tasks related to dynamic impacts [4].

Polymer concrete composites are alternative, non-metallic, viscoelastic, quasi-isotropic structural materials. They have satisfying strength-deformation parameters, according to the requirements for construction material and very good damping properties [2, 3].

The research and practical implementation of these construction materials and effective technologies is a modern trend for engineering production, both globally and for our country. Therefore the purpose of the present study is: Conducting a study to determine the dynamic modulus of linear deformations caused by longitudinal vibrations during hardening of polymer concrete mixture, using experimental modal analysis.

## 2. Methodology of the experiment

The procedure for determining a basic longitudinal resonance frequency, according to the standard ASTM E1876-09 [5]:

- Support the specimen at the midpoint of its length and width (fig1), or brace the specimen at its mid length, the fundamental longitudinal nodal position.
- Locate the detecting transducer at the center of one of the end faces of the specimen.
- Strike the end face of the specimen opposite to the face where the transducer is located.
- Record the resultant reading, and repeat the test, until five consecutive readings are obtained that lie within 1 % of each other. Use the average of these five readings to determine the fundamental longitudinal resonant frequency.

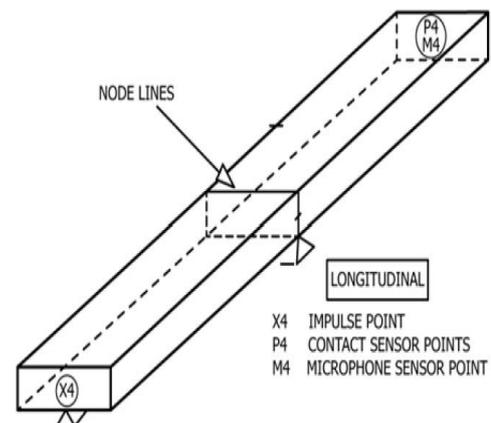


Fig.1 Rectangular Specimen Tested for Longitudinal Vibration

For the fundamental longitudinal frequency of a slender bar with rectangular cross-section:

$$E = 16mf_l^2 \left[ \frac{L}{\pi D_c^2 K} \right] \quad (1)$$

where:

$fl$  = fundamental longitudinal frequency of bar, Hz

$K$  = correction factor for the fundamental longitudinal

mode:

$$K = 1 - \left[ \frac{\pi^2 \mu^2 D_e^2}{8L^2} \right] \quad (2)$$

where:

$\mu$  = Poisson's ratio

$$D_e^2 = 2 \frac{b^2 + t^2}{3} \quad (3)$$

where:

$b$  = the width of the rectangular cross-section, mm

$t$  = the thickness of the rectangular cross-section, mm

## 3. Experimental results

The experimental samples have shape of a rectangular parallelepiped (beam type) with dimensions of 30x30x370 mm, in accordance to standardization norms.

3 samples were cast to minimize random errors. (fig 2.)



Fig. 2. Casted samples.

The experimental setup for determining the dynamic modulus E is shown in Fig. 3.



Fig. 3. Experimental setup

The obtained experimental results for values of the modules of the linear deformations of the experimental polymer concrete composition by days after the calculations are presented in table 1.

Values for the fundamental longitudinal frequencies were determined from the frequency spectra obtained during pulsed excitation of the experimental samples, Fig. 5 - 9.

Table 1: Experimental results for the modules

	No	f1 [Hz]	L [m]	E [Pa]
Day 5	1	4210	0.37	1.88E+10
	2	4204	0.37	1.87E+10
	3	4204	0.37	1.87E+10
Day 7	1	4191	0.37	1.86E+10
	2	4196	0.37	1.86E+10
	3	4183	0.37	1.85E+10
Day 13	1	4245	0.37	1.91E+10
	2	4247	0.37	1.91E+10
	3	4245	0.37	1.91E+10
Day 18	1	4253	0.37	1.91E+10
	2	4237	0.37	1.90E+10
	3	4274	0.37	1.93E+10
Day 21	1	4247	0.37	1.91E+10
	2	4242	0.37 </tr	

The percentage change between the maximum and minimum value of the module is determined. The results are presented in Table 2.

Table 2: Change of the modulus

	4.1	4.2	4.3
Day 5	1.88E+10	1.87E+10	1.87E+10
Day 7	1.86E+10	1.86E+10	1.85E+10
Day 13	1.91E+10	1.91E+10	1.91E+10
Day 18	1.91E+10	1.90E+10	1.93E+10
Day 21	1.91E+10	1.90E+10	1.91E+10
Delta	3.0%	2.5%	4.4%
	3.28%		

The obtained results are presented graphically in fig.4

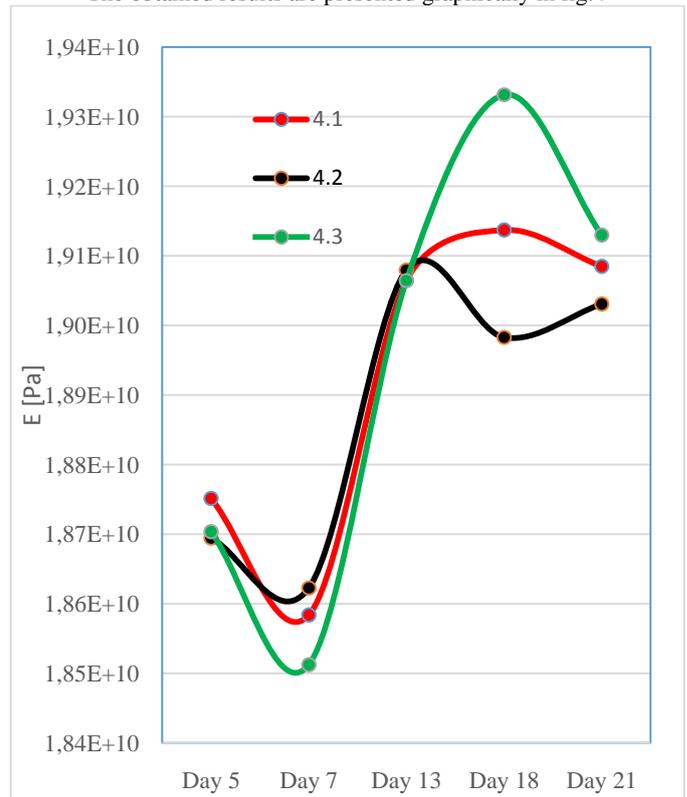


Fig. 4. Dynamic modulus



Fig. 5. Frequency spectrum (sample 1, day 5)

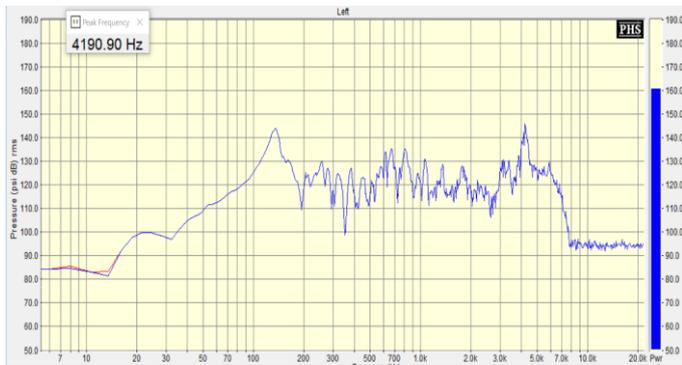


Fig. 6. Frequency spectrum (sample 1, day 7)



Fig.7. Frequency spectrum (sample 1, day 13)

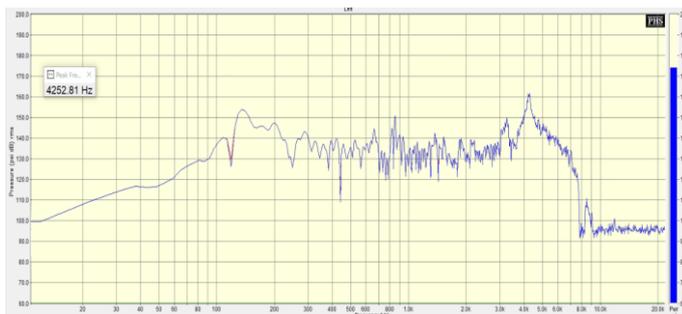


Fig. 8. Frequency spectrum (sample 1, day 18)



Fig. 9. Frequency spectrum (sample 1, day 21)

#### 4. Analysis of the obtained results

An analysis of the results obtained for the dynamic modulus of linear deformations from longitudinal vibrations was made and the following conclusions are drawn:

- Change is between 2.5% ÷ 4.4%.
- The possibilities of obtaining reliable information about the modules for this type of composites with the proposed methodology and measuring equipment are real and adequate
- When determining the dynamic modulus, the fundamental longitudinal frequencies of the examined samples were taken into account from their frequency spectrum.

As a conclusion from the conducted experiments, it is necessary to conclude that during the hardening of the polymer concrete mixture, the modulus remains significantly constant. Its average variation is 3.28%, which can be assumed to be a measurement error.

#### 5. References

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