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EXPERIMENTAL INVESTIGATION OF SEISMIC PERFORMANCE OF POLYMER COMPOSITE REINFORCED AAC FACHWERK WALL SYSTEMS UNDER VIBRODYNAMIC LOADING

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Abstract: This study presents an experimental investigation of the seismic performance of lightweight AAC masonry wall systems reinforced with polymer composite fachwerk profiles under vibrodynamic loading conditions. The primary objective of the research was to evaluate the dynamic behavior, stiffness characteristics, vibration stability, resonance response, and energy dissipation capacity of composite-reinforced wall systems subjected to simulated earthquake excitation. A full-scale experimental specimen consisting of AAC blocks with density class D600 integrated into a reinforced concrete frame and strengthened using polymer composite angle and sheet profiles $50 \times 50 \times 5$ mm was constructed and tested on a servo-hydraulic seismic vibration platform. Additional basalt mesh reinforcement was incorporated between masonry layers to improve crack resistance and structural integrity. The experimental program included harmonic seismic excitation corresponding to earthquake intensities from 5 to 9 points according to the MSK-64 scale. Dynamic response measurements were performed using high-precision accelerometers and LVDT displacement transducers. Acceleration histories, displacement responses, resonance behavior, and vibration characteristics were analyzed in both time and frequency domains. Fast Fourier Transform (FFT) analysis revealed dominant resonance frequencies near 1.99 Hz and 2.96 Hz, corresponding to the primary vibration modes of the investigated system. The polymer composite reinforcement significantly improved lateral stiffness, reduced drift response, enhanced damping capacity, and limited crack propagation during seismic excitation. The results demonstrated that the lightweight composite-reinforced wall system maintained structural integrity without catastrophic failure even under increased vibration amplitudes and near-resonance conditions. The viscoelastic behavior of the polymer matrix contributed to improved energy dissipation and suppression of excessive dynamic amplification. Compared with conventional steel reinforcement systems, the proposed polymer composite fachwerk system exhibited reduced seismic mass, superior corrosion resistance, improved deformation compatibility, and enhanced seismic efficiency. The findings of this research confirm the strong potential of polymer composite fachwerk systems for application in earthquake-resistant lightweight buildings, modular construction systems, and seismic retrofitting of masonry structures located in high seismic regions.

Keywords: Polymer composite, fachwerk system, AAC masonry wall, seismic behavior, vibrodynamic testing.

Introduction. The rapid growth of urbanization and the increasing demand for high-rise and large-span structures in seismic regions have significantly intensified the need for lightweight, durable, and earthquake-resistant structural systems [1,2]. Conventional masonry infill walls and traditional steel-based framing systems often exhibit substantial limitations under dynamic loading conditions due to their excessive self-weight, susceptibility to corrosion, and brittle failure mechanisms during seismic events. In earthquake-prone regions, especially in Central Asian countries such as Uzbekistan, where seismic intensity may reach

8–9 points according to the MSK-64 scale, the development of innovative structural systems capable of dissipating seismic energy while maintaining structural integrity has become a critical engineering challenge.

Recent advances in composite materials technology have created new opportunities for the application of polymer composite systems in civil engineering structures. Fiber-reinforced polymer (FRP) composites, including glass fiber reinforced polymer (GFRP), carbon fiber reinforced polymer (CFRP), and basalt fiber reinforced polymer (BFRP), possess high specific strength, low density, excellent corrosion resistance, and favorable fatigue characteristics [3,4]. These advantages make polymer composites highly attractive for seismic-resistant structural applications, particularly in lightweight framing and strengthening systems.

The density of conventional structural steel is approximately: $\rho_{steel} = 7850\ kg/m^3$ whereas polymer composite materials typically possess densities in the range of: $\rho_{FRP} = 1600–1900\ kg/m^3$ which results in a significant reduction in structural mass. Since seismic inertia forces are directly proportional to mass:

$$F = ma; \quad (1)$$

the reduction of structural self-weight directly contributes to the decrease of seismic forces acting on the system.

In recent decades, numerous researchers have investigated the seismic behavior of masonry infill walls, reinforced concrete frames, and steel bracing systems. However, despite extensive studies on reinforced masonry and steel-based strengthening techniques, the dynamic performance of lightweight AAC (Autoclaved Aerated Concrete) masonry systems reinforced with polymer composite fachwerk frames remains insufficiently explored. Existing studies mainly focus on static loading conditions, while limited experimental data are available regarding the vibrodynamic behavior of composite-reinforced AAC wall systems under real-time seismic excitation [5,6].

Moreover, traditional steel strengthening systems frequently encounter several disadvantages, including:

- corrosion under aggressive environmental conditions;
- increased dead load;
- welding-induced residual stresses;
- maintenance difficulties;
- reduced durability in humid environments.

Polymer composite profiles can potentially overcome these shortcomings due to their non-corrosive nature and high strength-to-weight ratio. In particular, composite angle and sheet profiles integrated into a fachwerk-type structural system may significantly improve the seismic resistance and deformation capacity of AAC masonry walls.

Experimental studies conducted in recent years demonstrate that lightweight structural systems reinforced with FRP components exhibit improved seismic energy dissipation and reduced crack propagation compared to conventional masonry systems. Nevertheless, there remains a substantial lack of comprehensive vibrodynamic investigations involving full-scale or semi-scale experimental specimens subjected to controlled seismic simulations [7,8].

In the present study, a large-scale experimental investigation was carried out on a lightweight AAC masonry wall reinforced using polymer composite profiles and basalt mesh reinforcement. The tested structure consisted of AAC blocks with dimensions of $625 \times 250 \times 250$ mm and density class D600, integrated into a reinforced concrete frame and strengthened using composite angle and sheet profiles measuring $50 \times 50 \times 5$mm.

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The experimental setup was constructed at the seismic testing laboratory of Turin Polytechnic University in Tashkent using a vibrodynamic platform capable of reproducing earthquake accelerograms within a frequency range of 0–20 Hz and displacement amplitudes up to ±100 mm.

Furthermore, the study contributes to the development of lightweight seismic-resistant wall systems suitable for high-rise buildings located in regions of high seismic hazard. The obtained results may serve as a scientific basis for updating regional seismic design recommendations and expanding the practical implementation of polymer composite structural systems in earthquake engineering.

Therefore, the main objective of this research is to experimentally and analytically investigate the seismic performance, dynamic stiffness, deformation behavior, and vibration characteristics of AAC masonry walls reinforced with polymer composite fachwerk systems under controlled vibrodynamic loading conditions.

MATERIALS AND METHODS

General Research Methodology. The present research was carried out through a comprehensive experimental vibrodynamic investigation of a lightweight wall system reinforced with polymer composite fachwerk elements under simulated seismic loading conditions. The study combined full-scale laboratory testing, dynamic response measurements, spectral signal analysis, and theoretical structural mechanics approaches in order to evaluate the seismic resistance and dynamic behavior of the proposed structural system.

The adopted methodology consisted of the following major stages:

1. Design and fabrication of the experimental specimen;
2. Installation of polymer composite framing elements;
3. Construction of AAC block masonry infill;
4. Integration of basalt mesh reinforcement;
5. Instrumentation using accelerometers and displacement transducers;
6. Vibrodynamic excitation using a servo-hydraulic seismic platform;
7. Recording of acceleration and displacement responses;
8. FFT-based spectral analysis of measured signals;
9. Evaluation of dynamic stiffness, resonance frequencies, and structural stability.

The experimental methodology was developed in accordance with the requirements of seismic testing standards including:

- GOST 30546.1-98;
- GOST 30546.2-98;
- GOST 30546.3-98;
- GOST 30630.0.0-99;
- GOST 30630.1.1-99;
- GOST 30630.1.2-99;
- GOST 30631-99;
- GOST R 52892-2007.

The experimental work was conducted at the Scientific and Technical Laboratory for Experimental Research of Buildings and Structures at Turin Polytechnic University in Tashkent.

Description of Experimental Specimen. The investigated structural system consisted of a reinforced concrete frame infilled with lightweight AAC (Autoclaved Aerated Concrete) masonry blocks and strengthened using polymer composite fachwerk profiles.

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The reinforced concrete frame dimensions were: $6400 \times 3500 \times 300\,mm$ and the specimen was mounted on a specialized seismic testing platform.

The wall infill was constructed using AAC blocks of density class D600 with dimensions: $625 \times 250 \times 250\,mm$ which are widely used in modern lightweight building systems due to their low self-weight and thermal insulation characteristics.

The polymer composite reinforcement system included:

- composite angle profiles;
- composite sheet profiles;
- I-shaped composite profiles.

All profiles possessed identical geometric and mechanical properties. The primary strengthening members had dimensions: $50 \times 50 \times 5\,mm$ and were integrated into the frame to form a lightweight fachwerk-type strengthening system.

The general arrangement of the experimental specimen is illustrated in the schematic configuration presented in the report.

Mechanical Properties of Polymer Composite Materials. The polymer composite profiles utilized in this investigation were manufactured using fiber-reinforced polymer technology and exhibited high strength-to-weight characteristics.

The experimentally determined mechanical properties of the composite materialwere as follows.

Tab 1.

Property	**Value**
Density	1.6–1.9 g/cm³
Tensile strength	731 MPa
Compressive strength	956 MPa
Flexural strength	614 MPa
Shear strength	132 MPa

The relatively low density of the composite material contributed to substantial reduction of the total structural mass, which is highly advantageous under seismic loading conditions because inertial forces are proportional to mass.

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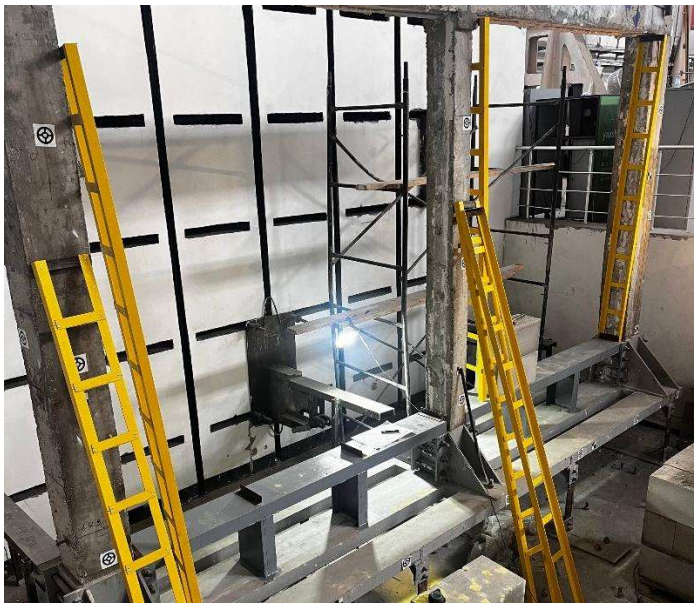


Figure 1. Installation process of polymer composite fachwerk profiles integrated into the AAC masonry wall system.

The tensile stress within the composite members can be expressed as:

$$\sigma = \frac{N}{A}; \quad (2)$$

where: N – is the axial force; A – is the effective cross-sectional area.

The elastic deformation of the composite members was determined according to:

$$\Delta l = \frac{Nl}{EA}; \quad (3)$$

where: E – is the elastic modulus of the composite material; l – is the member length.

Because polymer composites exhibit anisotropic behavior, the stiffness properties vary depending on fiber orientation:

$$E_x \neq E_y \neq E_z; \quad (4)$$

This anisotropy significantly influences dynamic stiffness and vibration response characteristics.

Seismic Testing Platform. The experimental investigations were carried out using a servo-hydraulic seismic vibration platform capable of reproducing dynamic earthquake-like excitations. The platform dimensions were: $6.5\ m \times 1.5\ m$ and the system was equipped with a high-capacity servo-hydraulic actuator for generating controlled dynamic loading.

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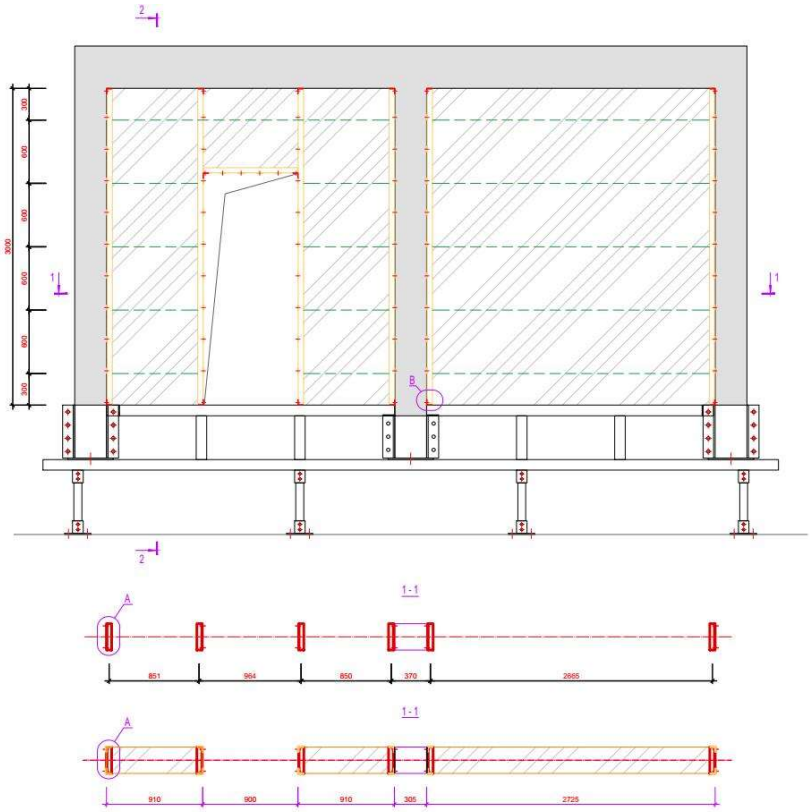


Figure 2. General view of the experimental composite-reinforced AAC wall system mounted on the seismic vibration platform. The platform was capable of producing:

- harmonic excitation;
- random vibration;
- impulse loading;

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- resonance search and dwell tests;
- sweep sine excitation.

The technical characteristics of the testing system were.

Tab 2.

Parameter	Value
Maximum harmonic force	25 kN
Maximum random force	30 kN
Maximum impact force	50 kN
Maximum acceleration	±2.0 g
Maximum velocity	812 mm/s
Maximum displacement	±100 mm
Frequency range	0–20 Hz

The excitation frequencies selected for the present study ranged from:

$0.5\ Hz \leq f \leq 10\ Hz$; (5)

which corresponds to the dominant frequency range of many low- and medium-rise structures during seismic events.

Dynamic Loading Procedure. The seismic simulations were conducted using sinusoidal dynamic loading corresponding to different seismic intensity levels according to the MSK-64 scale.

The loading stages included:

- 5-point seismic excitation;
- 6-point seismic excitation;
- 7-point seismic excitation;
- 8-point seismic excitation;
- 9-point seismic excitation.

The experiments were performed using varying:

- excitation frequencies;
- displacement amplitudes;
- vibration durations.

Typical loading parameters included:

- 1 Hz frequency with 10 mm amplitude;
- 2 Hz frequency with 10 mm amplitude;
- 1 Hz frequency with 20 mm amplitude;
- 2 Hz frequency with 20 mm amplitude.

The dynamic loading was applied perpendicular to the wall plane in order to generate maximum structural response and simulate realistic seismic conditions.

EXPERIMENTAL RESULTS

General Dynamic Behavior of the Composite Fachwerk System. The experimental vibrodynamic investigations demonstrated that the proposed polymer composite reinforced AAC wall system exhibited stable seismic behavior under both low- and medium-intensity earthquake simulations. During the testing process, the interaction between the AAC masonry

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infill, polymer composite framing profiles, and basalt mesh reinforcement created a unified hybrid structural mechanism capable of efficiently redistributing seismic forces and dissipating dynamic energy.

Unlike conventional unreinforced masonry walls, which often experience brittle failure during seismic excitation, the investigated wall system exhibited gradual deformation development and controlled stiffness degradation. This behavior can primarily be attributed to the lightweight nature of the composite profiles and their enhanced deformation compatibility with AAC blocks.

The seismic inertial force acting on the structure is governed by Newton's second law:

$$F = ma; \quad (6)$$

where: F— seismic inertia force; m— structural mass; a— acceleration.

Because the density of the composite material was significantly lower than that of structural steel: $\rho_{FRP} = 1.6–1.9\ g/cm^3$ the total seismic mass of the system was reduced considerably. Consequently, earthquake-induced inertia forces acting on the wall were substantially lower than those expected in conventional steel-framed systems.

The experiments further demonstrated that the composite reinforcement system effectively:

- improved lateral rigidity;
- reduced dynamic amplification;
- controlled crack propagation;
- enhanced vibration damping.

The displacement response of the wall followed a harmonic oscillatory pattern under low-frequency excitation:

$$x(t) = A\sin(\omega t); \quad (7)$$

where: A— vibration amplitude; ω— excitation frequency.

At low seismic intensities corresponding to 5 points on the MSK-64 scale, the structural response remained predominantly linear elastic, and no visible structural damage was observed.

Dynamic Displacement Response

Response under 1 Hz Harmonic Excitation. The first stage of the experiment was conducted under harmonic excitation with:

- excitation frequency: $f = 1\ Hz$;
- semi-amplitude: $A = 10\ mm$.

During this loading stage, the wall exhibited stable sinusoidal vibration behavior without significant nonlinear effects. The measured displacement histories indicated that the upper regions of the wall experienced larger lateral deformations than the lower regions due to flexural deformation of the frame-wall system.

The experimentally recorded displacement values were approximately:

$$\Delta_{TR} \approx 5.2\ mm$$
$$\Delta_{TL} \approx 4.5\ mm$$
$$\Delta_{BR} \approx 2.8\ mm$$
$$\Delta_{BL} \approx 2.5\ mm$$

The displacement amplification ratio between upper and lower wall regions was determined as:

$$\eta = \frac{\Delta_{top}}{\Delta_{bottom}}; \quad (8)$$

yielding: $\eta \approx 1.8$

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This result confirms that the wall system primarily behaved as a flexural cantilever-type structure during the initial excitation stage.

The displacement-time histories remained smooth and regular, indicating the absence of abrupt stiffness loss or local instability. The AAC masonry and composite framing system demonstrated good interaction compatibility during vibration.

The effective lateral stiffness of the wall system was estimated using:

$$k = \frac{F}{\Delta}; \quad (9)$$

Assuming:

- lateral force: $F \approx 25\ kN$
- displacement: $\Delta \approx 5\ mm$

the effective stiffness becomes:

$$k = \frac{25 \times 10^3}{0.005}$$

$$k \approx 5 \times \frac{10^6\ N}{m}$$

The relatively high stiffness value confirms the significant contribution of the composite fachwerk reinforcement to the global lateral resistance of the wall.

Moreover, no visible cracks or connection failures were detected after completion of this loading stage, demonstrating adequate elastic performance of the proposed system.

Response under 2 Hz Harmonic Excitation. When the excitation frequency increased to: $f = 2\ Hz$ the wall system demonstrated significantly larger displacement amplitudes due to the proximity of the excitation frequency to the natural vibration frequencies of the structure.

The maximum measured displacements increased to: $\Delta_{max} \approx 7–8\ mm$**.** The increase in displacement amplitude indicates the development of partial resonance amplification effects within the wall system.

The dynamic response of the structure can be described by the forced vibration equation:

$$m\ddot{x} + c\dot{x} + kx = P_0 \sin(\omega t); \quad (10)$$

where: m— equivalent mass; c— damping coefficient; k— stiffness; P_0— excitation force amplitude.

The increased displacement response was especially noticeable near the upper corners of the wall, where dynamic amplification effects were strongest. Despite the increased amplitudes:

- no global instability occurred;
- no local buckling was observed;
- no fracture of composite profiles developed.

This demonstrates that the composite reinforcement system effectively redistributed seismic forces and prevented localized overstressing.

The vibration decay after termination of excitation occurred rapidly due to the inherent damping properties of the polymer composite material. The viscoelastic polymer matrix contributed significantly to internal energy dissipation.

Acceleration Response Characteristics

Dynamic Acceleration Amplification. Acceleration response analysis demonstrated that the upper regions of the wall experienced significantly larger acceleration amplitudes than the lower support regions.

The measured acceleration amplification coefficient was determined using:

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$$\beta = \frac{a_{top}}{a_{bottom}}; \quad (11)$$

The experimentally measured acceleration values reached:

$$a_{top} \approx 150\ cm/s^2$$

$$a_{bottom} \approx 30\ cm/s^2$$

this:

$$\beta = \frac{150}{30} = 5$$

This indicates considerable dynamic amplification near the upper wall region.

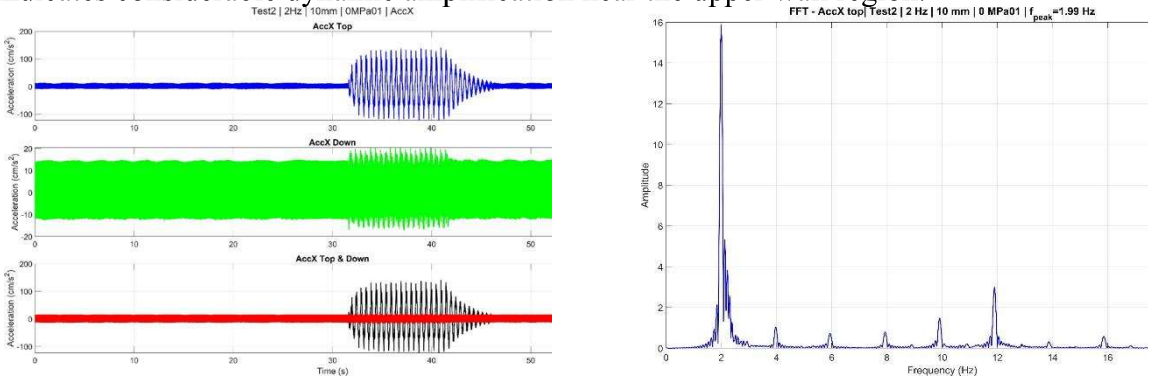


Figure 3. Acceleration response of the composite-reinforced AAC wall under harmonic seismic excitation.

The acceleration histories remained stable without chaotic oscillations or abrupt acceleration spikes. This demonstrates that the composite framing system effectively controlled dynamic instability and maintained vibration regularity.

The observed acceleration response also confirmed that the wall system behaved as a flexible lightweight dynamic structure rather than a rigid masonry panel.

Influence of Resonance on Acceleration Growth. As the excitation frequency approached the natural frequencies of the structure, acceleration amplitudes increased substantially.

The resonance condition is expressed as:

$$f \approx f_n; \quad (12)$$

where: f— excitation frequency; f_n— natural frequency.

The experimentally obtained resonance frequencies were approximately: $f_1 \approx 1.99\ Hz$; $f_2 \approx 2.96\ Hz$.

These frequencies correspond to:

- the first global flexural vibration mode;
- the second local interaction mode between the AAC masonry and composite frame.

The resonance amplification factor is given by:

$$DAF = \frac{1}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}; \quad (13)$$

where: $r = \omega/\omega_n$; ζ— damping ratio.

The relatively high damping characteristics of the polymer composite system prevented excessive resonance amplification and limited displacement growth.

FFT Spectral Analysis. Fast Fourier Transform (FFT) analysis was conducted on all acceleration signals to identify the dominant vibration modes and frequency-domain characteristics of the wall system.

The Fourier transform is expressed as:

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$$X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-i2\pi ft} dt; \quad (14)$$

The FFT spectra clearly showed dominant spectral peaks near:

- 1.99 Hz;
- 2.96 Hz.

The first dominant frequency:

$$f_1 \approx 1.99\ Hz$$

corresponded to the global out-of-plane flexural vibration mode of the wall. The second frequency:

$$f_2 \approx 2.96\ Hz$$

represented localized interaction between:

- composite framing members;
- AAC masonry blocks;
- basalt mesh reinforcement.

Higher-order spectral peaks within: 8–12 Hz were associated with local stiffness interactions and micro-vibration behavior of the masonry joints.

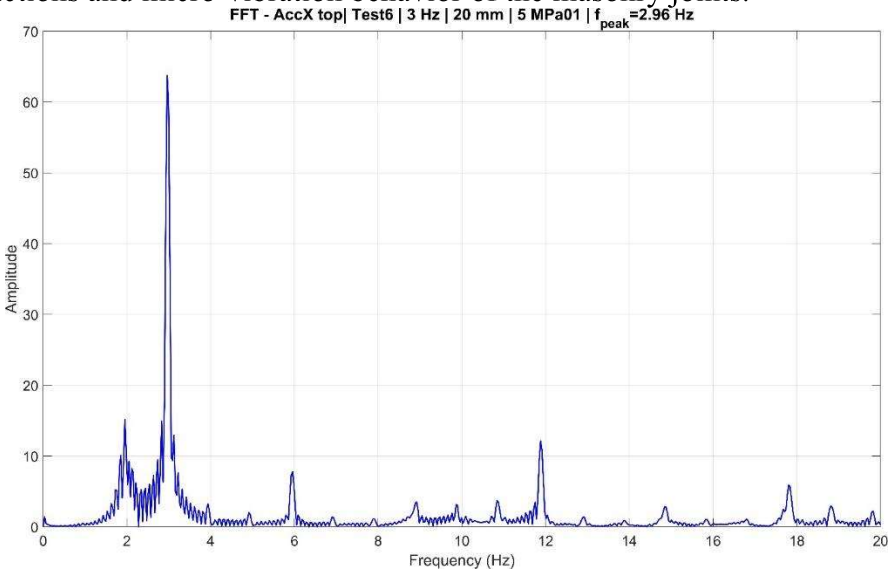


Figure 4. FFT spectrum of the wall acceleration response showing dominant resonance frequencies.

The FFT analysis demonstrated that the polymer composite reinforcement significantly modified the dynamic characteristics of the wall system and improved vibration stability.

Interstory Drift and Lateral Stability. The interstory drift ratio was evaluated according to:

$$\theta = \frac{\Delta}{H}; \quad (15)$$

where: Δ— lateral displacement; H— wall height.

For: all height: $H = 3500\ mm$; maximum displacement: $\Delta = 10\ mm$

the drift ratio becomes: $\theta = \frac{10}{3500} = 0.00286$.

The obtained drift ratio remained within acceptable seismic design limits for lightweight wall systems. The composite fachwerk reinforcement significantly reduced:

- lateral drift;
- torsional deformation;
- out-of-plane instability.

The increased lateral stiffness provided by the composite profiles improved deformation compatibility between the masonry infill and reinforced concrete frame.

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Crack Formation and Damage Evolution. Visual inspections performed after each loading stage revealed gradual and controlled crack development.

The observed damage mechanisms included:

- minor mortar cracking;
- local AAC block separation;
- corner cracking;
- interface cracking near profile connections.

Importantly:

- no collapse occurred;
- no fracture of composite profiles was observed;
- no major instability developed.

The tensile stress in the composite members remained below the ultimate material strength:

$$\sigma_{max} < \sigma_u; \quad (16)$$

where: $\sigma_u = 731\ MPa$

The basalt mesh reinforcement effectively limited crack widening and preserved structural integrity. The polymer composite profiles demonstrated excellent resistance against:

- tensile failure;
- local buckling;
- shear fracture.

The observed crack propagation process remained stable and progressive even at increased seismic amplitudes.

Energy Dissipation Characteristics. One of the most important findings of the experimental investigation was the high damping and energy dissipation capacity of the polymer composite fachwerk system.

The seismic energy balance is expressed as:

$$E_I = E_K + E_S + E_D; \quad (17)$$

where: E_I — input seismic energy; E_K — kinetic energy; E_S — strain energy; E_D — dissipated energy.

The kinetic energy of the vibrating structure is:

$$E_K = \frac{1}{2}mv^2; \quad (18)$$

while the elastic strain energy is:

$$E_S = \frac{1}{2}kx^2; \quad (19)$$

The polymer composite material substantially increased the dissipated energy component due to:

- internal matrix damping;
- microstructural viscoelasticity;
- frictional sliding between structural components.

Consequently, vibration amplitudes decayed rapidly after excitation termination, confirming the high damping efficiency of the composite reinforcement system.

Nonlinear Dynamic Behavior. As excitation amplitudes increased from: 10 mm; to: 20 mm and above, the structural response gradually transitioned from linear elastic behavior toward nonlinear dynamic behavior. This nonlinear response included:

- stiffness degradation;
- crack accumulation;
- local frequency shifting;
- hysteretic deformation.

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The effective stiffness reduction can be represented as:

$$k_{eff} < k_0; \quad (20)$$

where: k_0— initial stiffness; k_{eff}— degraded stiffness.

Despite nonlinear deformation development, the wall system maintained overall stability and avoided brittle failure mechanisms.

The polymer composite reinforcement effectively redistributed internal forces and delayed severe damage accumulation.

DISCUSSION

The experimental investigations demonstrated that the proposed polymer composite reinforced AAC wall system possesses significantly improved seismic performance compared to conventional lightweight masonry walls. The integration of polymer composite fachwerk profiles and basalt mesh reinforcement substantially enhanced the structural stiffness, vibration stability, crack resistance, and energy dissipation characteristics of the wall system under dynamic excitation.

The obtained results clearly indicate that the seismic behavior of lightweight masonry structures strongly depends on:

- structural mass;
- lateral stiffness;
- damping capacity;
- deformation compatibility between components.

One of the principal advantages of the investigated system was the considerable reduction of structural self-weight due to the use of polymer composite profiles instead of conventional steel elements. The seismic inertial force acting on the structure is governed by:

$$F = ma; \quad (21)$$

where: F— seismic inertia force; m— structural mass; a— seismic acceleration.

Because the density of the composite material:

$$\rho_{FRP} = 1.6\text{–}1.9\ g/cm^3$$

was significantly lower than structural steel density:

$$\rho_{steel} \approx 7.85\ g/cm^3$$

the resulting seismic inertia forces were considerably reduced.

This reduction in seismic mass directly improved the global seismic efficiency of the wall system.

Furthermore, the experiments confirmed that the polymer composite reinforcement system maintained stable structural behavior even under increasing vibration amplitudes and resonance conditions. Unlike conventional brittle masonry systems, the investigated wall demonstrated progressive nonlinear deformation development without sudden collapse mechanisms.

Influence of Polymer Composite Profiles on Structural Stiffness. One of the most significant findings of the investigation was the substantial increase in lateral stiffness provided by the composite fachwerk reinforcement system. The lateral stiffness of the wall can be expressed as:

$$k = \frac{F}{\Delta}; \quad (22)$$

where: F— lateral seismic force; Δ— horizontal displacement.

The experimental displacement results demonstrated relatively small lateral drift values despite increasing seismic excitation amplitudes. This indicates that the composite framing system effectively redistributed dynamic forces and reduced deformation concentration within the AAC masonry infill.

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The enhanced stiffness behavior can be attributed to:

- high tensile strength of composite profiles;
- efficient force transfer mechanisms;
- improved frame-wall interaction;
- reduced local deformation accumulation.

The polymer composite profiles possessed tensile strength values reaching: $\sigma_t = 731\ MPa$ and compressive strength values of: $\sigma_c = 956\ MPa$.

These relatively high mechanical properties enabled the composite elements to sustain dynamic tensile and compressive stresses without fracture or instability.

Moreover, the use of composite profiles eliminated corrosion-related deterioration commonly observed in steel strengthening systems, thereby improving long-term structural durability.

Resonance Behavior and Dynamic Stability. The FFT analysis revealed dominant vibration frequencies near: $f_1 \approx 1.99\ Hz$ and $f_2 \approx 2.96\ Hz$. These frequencies corresponded to the primary vibration modes of the wall system. The first mode primarily represented: global out-of-plane wall flexure; while the second mode was associated with: local interaction between AAC blocks and composite framing members.

The dynamic amplification factor near resonance is expressed by:

$$DAF = \frac{1}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}; \quad (23)$$

where: $r = \omega/\omega_n$; ζ— damping ratio.

Although resonance amplification was observed near the natural frequencies, the increase in vibration amplitudes remained controlled due to the relatively high damping capacity of the polymer composite material.

The experiments demonstrated that:

- no uncontrolled resonance growth occurred;
- no dynamic instability developed;
- no catastrophic stiffness degradation was observed.

This indicates that the polymer composite reinforcement system effectively suppressed excessive resonance amplification.

Damping Characteristics and Energy Dissipation. Another important observation was the enhanced damping capacity of the composite-reinforced wall system. The damping ratio is defined as:

$$\zeta = \frac{c}{2\sqrt{km}}; \quad (24)$$

where: c— damping coefficient; k— stiffness; m— mass.

Polymer composite materials possess inherent viscoelastic properties due to the polymer matrix structure. Consequently, the wall system exhibited:

- rapid vibration decay;
- reduced resonance amplitudes;
- improved seismic energy dissipation.

The total seismic energy balance is expressed as:

$$E_I = E_K + E_S + E_D; \quad (25)$$

where: E_I— input energy; E_K— kinetic energy; E_S— strain energy; E_D— dissipated energy.

The experiments demonstrated that the composite system substantially increased the dissipated energy component E_D, thereby reducing the amount of energy transferred into structural damage.The primary energy dissipation mechanisms included:

- internal matrix damping;
- friction between AAC blocks;
- basalt mesh interaction;
- microdeformation of composite profiles.

This behavior significantly improved the seismic resilience of the wall system.

CONCLUSION

The present study experimentally investigated the seismic behavior of a lightweight AAC masonry wall reinforced using polymer composite fachwerk profiles and basalt mesh reinforcement under controlled vibrodynamic loading conditions.

Based on the obtained experimental and analytical results, the following conclusions can be drawn:

1. The polymer composite reinforcement system significantly improved the seismic performance of the AAC wall structure by increasing lateral stiffness and reducing deformation concentration.

2. The low density of the polymer composite material substantially reduced seismic inertia forces acting on the structure: $F = ma$ thereby enhancing global seismic efficiency.

3. FFT spectral analysis identified dominant resonance frequencies near: $1.99\ Hz$ and $2.96\ Hz$ which correspond to the principal vibration modes of the wall system.

4. Despite resonance amplification effects, the wall system maintained stable vibration behavior without catastrophic stiffness degradation or collapse.

5. The polymer composite profiles demonstrated high mechanical performance with tensile strength reaching: $731\ MPa$ and compressive strength: $956\ MPa$ which ensured reliable load-bearing capacity during seismic excitation.

6. The basalt mesh reinforcement effectively limited crack propagation and preserved wall integrity during dynamic loading.

7. The investigated system exhibited enhanced damping and energy dissipation characteristics due to the viscoelastic behavior of the polymer matrix and frictional interaction between structural components.

8. Interstory drift values remained within acceptable seismic performance limits throughout the experimental program, confirming adequate lateral stability of the wall system.

9. No fracture of composite profiles, local buckling, or global instability was observed during the vibrodynamic experiments.

10. Compared with conventional steel strengthening systems, the polymer composite fachwerk system demonstrated superior corrosion resistance, lower structural mass, and improved compatibility with lightweight AAC masonry.

11. The proposed structural solution possesses significant potential for practical implementation in:

- earthquake-resistant buildings;
- lightweight infill wall systems;
- modular prefabricated structures;
- seismic retrofitting applications.

12. The obtained experimental results may serve as a scientific basis for further development of seismic design recommendations for polymer composite reinforced masonry systems in earthquake-prone regions.

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