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Behavior of welded gabion boxes in axial compression tests

Gisleine Coelho de Campos[1#], Rafael da Fonseca[2], Gelmo Chiari Costa[3]

Article

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Abstract

This article presents the results of innovative laboratory tests conducted on different types of cubic gabion boxes, each with approximate edge length of 1 m. The tests evaluated both confined and unconfined boxes subjected to compression stresses. In addition to the confinement factor, the experimental variables included the type of mesh, the presence of tie rods, and the apparent density. The primary goal was to conduct a comparative analysis of the deformability of the boxes by measuring their horizontal and vertical displacements under controlled conditions of uniformly distributed vertical loading. The results indicate that double-twist hexagonal mesh gabions, which are traditionally used in geotechnical applications in Brazil, can support less load. However, due to their woven mesh configuration and geometric characteristics, they exhibit greater flexibility, allowing for more significant deformations. In contrast, welded mesh gabions, which are square or rectangular and constructed with higher-strength, larger-gauge carbon steel wires, are capable of supporting higher loads. Comparative analyses of tests conducted with and without confinement revealed that, when the boxes are filled carefully, the tests without confinement can yield very satisfactory results in a simpler way.

1. Introduction

Gabions are versatile structures commonly used in civil engineering. They are made of wire mesh boxes that are filled with stones, providing a strong and durable construction method. These structures are effective in containing earth masses and can serve as barriers due to their own weight. Their design allows for significant deformation and excellent drainage capacity, making them valuable in various applications.

In Latin America, gabions are mainly made from woven galvanized carbon steel wires, which are coated with a zinc-aluminum alloy to form a double twist hexagonal mesh. This unique webbing technique involves twisting the wires double for each new hexagon created. In order to enable a manufacturing process for weaving meshes and technical performance, the wires used have mechanical resistance of about 400 MPa, and in a range of gauges from 2 to 3 mm for the most comprehensive part of the meshes. This is all based on the guidelines set by the Brazilian technical standards ABNT (1988, 2024).

Germany has made significant advancements in welded gabion technology, owing not only to its extensive history of industrial development in welded mesh platforms but also to an integrated quality management system that encompasses the entire production chain of gabion works. The two key international technical standards for welded mesh gabions are DIN (2013), and ASTM (2021).

Welded mesh gabions typically feature larger square or rectangular meshes, manufactured from thicker wires ranging from 3.00 to 6.00 mm in diameter. These wires possess mechanical resistance levels exceeding 500 MPa, which contributes to the gabions' enhanced robustness, stiffness, and self-portability. These characteristics make them suitable for various structural applications, facilitate the mechanization of filling, and allow for creative aesthetic possibilities.

Hexagonal and welded mesh gabions were tested under axial compression stress in various configurations. These configurations included gravity walls, facings for soil reinforcement structures, special barriers, and architectural applications. In all these scenarios, the structures experienced axial compression stress.

A metal gantry was utilized alongside a set of instruments for load measurement and application to conduct axial compression tests. This setup included linear variable displacement transducers (LVDTs), pulley deflectometers, load cells, and a hydraulic jack. Additionally, a reference system for displacement measurements was established using metal tubes and bases, along with a device for dragging and positioning the test boxes within the press.

#Corresponding author. E-mail address: gisleine@ipt.br
[1]Instituto de Pesquisas Tecnológicas do Estado de São Paulo S/A, Seção de Obras Civis, São Paulo, SP, Brasil.
[2]Instituto de Pesquisas Tecnológicas do Estado de São Paulo S/A, Seção de IoT, Transporte e Engenharia Conectada, São Paulo, SP, Brasil.
[3]Belgo Bekaert Arames Ltda., Contagem, MG, Brasil.

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The results from unconfined tests displayed significant variability in performance among the different boxes, which was directly linked to the type of mesh used and the positioning of the tie rods. In the confined tests, it was observed that the internal tie rods were subjected to lower stress, with the highest mobilization occurring in the elements connected to the free face of the box.

The stiffness and deformation of welded mesh gabions have been examined in various studies. For instance, Figure 1 presents an experimental case. The central point of this figure distinguishes between two types of gabions: the right-hand branch features hexagonal gabions, which experience immediate deformation due to their own weight, while the left-hand branch consists of welded gabions, which remain stable and retain the dimensions outlined in the project.

For hexagonal mesh gabions, there are several studies and published test results, such as the research conducted by Santos (2018). In contrast, the amount of publicly available data on welded gabions in Brazil is still limited. However, many welded gabion structures have been built that meet the project's performance requirements.

According to Rocha (2025), the performance of welded mesh gabions is influenced by various factors, including the properties of the metal meshes, the filling material, the geometry of the structure, and the loading conditions.

Additionally, the quality of the filling material is crucial and can be evaluated based on the density of the elements. This aspect is further elaborated by Karampinos et al. (2018), who highlighted the impact of the test configuration used in laboratory settings on the behavior of welded meshes through experimental tests and numerical modeling.

2. Gabion boxes characteristics

The boxes used in the laboratory compression tests had the characteristics outlined in Table 1. Boxes numbered 1 to 10 were tested without confinement, while boxes numbered 1A to 5A were tested under confined conditions, with only the front face exposed. This table includes columns detailing the specimen number, a description of the type of gabion tested, which may vary between double twist hexagonal mesh (referred to as Type A) and welded mesh.

An evaluation was conducted on two types of welded mesh gabions, both made up of panels welded from galvanized carbon steel wires with a zinc-aluminum alloy. The first type feature panels that have smooth edges and are assembled into boxes utilizing wire spiral connectors (Type B).

Figure 1. Experimental gabion wall: on the left, section in welded mesh gabion, and, on the right, in hexagonal mesh.

Table 1. Gabion boxes characteristics.

No.	Gabion types	Typology of tie rods or reinforcements.	Quantity and arrangement of the tie rods
01	Type A, hexagonal double twist mesh, 8x10 cm (2.70 mm wire gauge); edge connection element using lacing wire (2.20 mm)	Standard tie wire (2.20 mm)	2 rows of 2 crosswise ties, totaling 4 elements per m^2, symmetrically positioned at 1st and 2nd third. The above layout is duplicated in both directions of the box
02	Same as 01	High tensile tie wire (2.20 mm)	Same as 01
03	Type B, modular welded mesh, 5x10 cm (4.00 mm wire gauge); wire spiral connectors (4.50 mm)	Pre-formed ties with 5.00 mm diameter and loops bent using pliers or similar tools	2 rows of ties, each row containing 2 transverse ties (1 m long) and 4 corner ties (0.50 m long), positioned at 30/30 cm height intervals from the base
04	Same as 03	Same as 03	3 rows of ties, each row containing 2 transverse ties (1 m long) and 4 corner ties (0.50 m long), positioned at 20/30/30 cm height intervals from the base
05	Same as 03	Pre-formed ties with 5.00 mm diameter adopting the loops fastened using metal clamps	Same as 03
06	Type B, modular welded mesh, 10x10 cm (4.00 mm wire gauge); wire spiral connectors (4.50 mm)	Same as 03	Same as 03
07	Same as 03	Same as 03	Same as 03
08	Same as 03	Same as 03	Same as 04
09	Type B, modular welded mesh, 5x10 cm for vertical pannels and 10x10 cm for horizontal pannels (4.00 mm wire gauge); wire spiral connectors (4.50 mm)	Same as 03	Same as 03
10	Type C, modular welded mesh, 10x10 cm (4.50 mm wire gauge); the edges of the panels present eyelet that are interconnected by a 6.00 mm wire pin	Same as 03	Same as 03
1A	Same as 03	Same as 03	Same as 03
2A	Same as 09	Same as 03	Same as 03
3A	Same as 09	Same as 03	Same as 03
4A	Type B, economic modular mixed welded mesh: 5x10 cm visible vertical face / 10x10 cm others (4.00 mm wire gauge); wire spiral connectors (4.50 mm)	Same as 03	Same as 03
5A	Same as 01	Same as 01	Same as 01

Notes: The numerical references from 01 to 10 correspond to the specimens subjected to uniaxial compression testing without lateral expansion restraint. For the references from 01A to 05A, the test was conducted using a metal box to restrain lateral expansion on three vertical faces.

The second type is designed with panels that incorporate welded eyelets. These eyelets permit the introduction of a wire pin to securely join the edges of the boxes (Type C).

Reinforcing wire elements are commonly used to connect the vertical faces of each gabion box. These elements, often referred to as ties, perform a crucial role in controlling the horizontal deformation of the faces. This study evaluated three types of tie rods: manually made with conventional lancing wire (2.20 mm), made from high-tensile strength wire (2.20 mm), and industrially preformed with 5.00 mm wires featuring folding handles. Each box was tied horizontally in two orthogonal directions. Additionally, the number of tie lines varied, with either two or three lines of prefabricated ties used. The stone material selected for filling the gabions consists of crushed rock and polyhedral paving stone. Crushed rock is commonly referred to as cobblestone, categorized as hand stone with an equivalent diameter of 150 to 300 mm. Polyhedral paving stone is commonly referred to as cobblestone, with a diameter ranging from 100 to 150 mm.

3. Laboratory infrastructure

The gabion box tests were conducted using the gantry shown in Figure 2, which has a capacity of up to 1,000 kN. Loads were applied with a hydraulic jack, and a load cell was utilized for precise control during both the loading and unloading phases.

All measuring devices were calibrated beforehand. In order to measure vertical displacements, it was employed LVDTs (Linear Variable Displacement Transducers) with a nominal stroke of 100 mm. These were supported on glass plates that were glued to the ends of a steel plate used for load distribution. Additionally, LVDTs were used to measure horizontal displacements, arranged horizontally on acrylic discs, which were fixed to a spring and galvanized wire system to monitor the horizontal movements of the steel mesh in the box.

In the unconfined tests, an LVDT system was installed on two sides of the box, with measurements taken at four different positions along the height, ensuring that an instrument was always positioned at the heights corresponding to the location of the internal tie rods. On the other two sides, a pulley deflectometer was placed at the center of the plane. For the confined tests, a rigid metal box, as shown in Figure 3, was utilized. All displacement measuring devices were mounted on fixed reference systems that were specifically assembled for the tests.

4. Testing methodology

For the unconfined tests (CPs 1 to 10), the gabion boxes were delivered to the laboratory on wooden pallets. The dimensions of each box were recorded in a spreadsheet, accompanied by photographic documentation. Following the measurement of dimensions, the mass of each box was determined to calculate its density.

In order to position the boxes within the testing apparatus, a dragging device was constructed, comprising metal angles, steel cables, and a hydraulic system. This design aims to minimize any deformation of the boxes during both the transport and assembly phases of the test. Following the positioning of the boxes in the system, the dimensions were recorded once again to identify any alterations that may have occurred to their initial geometry as a result of the process.

The tests were conducted using a rapid loading methodology, organized into 10 stages with each stage applying approximately 60 kN for an average duration of 10 minutes, culminating in a maximum load of 600 kN or until the failure of the box occurred. The duration of each stage exhibited variability due to challenges in maintaining the loads attributed to the deformability of the boxes. The loads were applied by a hydraulic jack and load cell assembly, utilizing a load distribution system comprised of steel plates positioned on the boxes. For the unloading phase, the initial plan was to proceed in 5 stages of 120 kN each, with a

Figure 2. Apparatus used in unconfined tests.

Figure 3. Metal box for confinement.

duration of 5 minutes per stage. Following an analysis of the initial test results, modifications were made to the loading stages, which were adjusted to 30 kN with a duration of 5 minutes for each loading phase. In cases where unloading was allowed, three to four stages were implemented, with a minimum duration of 2 minutes assigned to each stage.

The load values were measured using a load cell. Vertical and horizontal displacements were recorded with LVDTs and pulley deflectometers, achieving an accuracy of 0.01 mm. Four instruments (D1 to D4) measured vertical displacements on the upper surface of the blocks, adjacent to the load distribution plate. An additional ten instruments were used to measure horizontal displacements on the vertical planes of the four faces: D5 to D8 on Face A, D9 to D12 on Face B, D13 on Face C, and D14 on Face D. Steel cables were secured to nodes on the screen within the vertical planes, serving as reference points for measuring displacements. On Faces A and B, four points were designated for measuring horizontal displacements: two along the lines of the tie rods and two in intermediate positions, which varied based on the box type. On Faces C and D, opposite Faces A and B, a single pulley deflectometer was positioned at the center of the height for measurement.

All displacement sensors were installed on fixed reference systems that were independent of the loading gantry. At each stage of loading, a visual assessment and photographic documentation were conducted to identify any occurrences such as elements ruptures, excessive deformations, or stone leakage.

For the confined tests (CPs 1A to CP 5A), the confinement box, which has internal dimensions of 1.04 m × 1.04 m × 1.00 m, was initially positioned and secured in the testing apparatus. After that, a set of stones previously used to fill CPs 4 and 7 was gathered to fill the new CPs.

The gabion box was then assembled, along with the lid and the steel load distribution plate, onto which the load cell was attached. The load distribution system and the load cell indicate a total weight of 4.23 kN placed on the gabion box. Under this load, the initial readings (zero) of all instruments were established. Four instruments were used to measure the vertical displacements (D1 to D4) on the upper face of the boxes, near the load distribution plate. Additionally, six instruments (D5 to D10) were distributed on the vertical plane of the free face to measure horizontal displacements. The free front face of the confined tests corresponds to face A of the unconfined tests, which is the face used to calculate the horizontal deformations of the boxes.

The tests were conducted by gradually applying loads in increments of approximately 40 kN, with each increment lasting an average of two minutes. This process continued until a maximum load of 800 kN was reached, until the box ruptured, or until a maximum vertical displacement of 230 mm was achieved, which is the maximum limit of the hydraulic jack piston. The duration of each loading stage varied slightly due to challenges in maintaining the loads, caused by the deformability of the different boxes. Throughout the test, displacement measurements were taken, and photos and videos were recorded during both the loading and unloading phases. This documentation was essential for understanding the evolution of the deformation on the free face and for capturing any potential ruptures in the mesh, welding points, and tie rods. The unloading process was carried out in ten stages, each involving a load reduction of 80 kN, and lasted approximately one minute.

5. Results

The results obtained from the conducted tests are presented below, focusing on the maximum displacements measured during the loading of the boxes, as well as the relationship between vertical stress and deformation.

5.1 Unconfined tests

The findings demonstrate that hexagonal mesh gabions (Type A), which are traditionally employed in geotechnical applications in Brazil and are characterized by their double twist design, exhibit a lower load-bearing capacity, with a maximum value of 326 kN. It is important to note, as mentioned in item 4, that all the non-confined CPs were pre-filled at a specific site before being transported to the laboratory. This process affects how the stones are arranged, especially in boxes with lower rigidity. Hexagonal mesh gabions, due to their mesh configuration and geometric properties, possess enhanced flexibility (Figure 4).

Welded mesh gabions, constructed from higher-strength, larger-gauge carbon steel wires with a greater steel content per volumetric unit, are capable of supporting loads of approximately 580 kN. The deformations associated with these structures are directly influenced by various factors, including the quality of the top filling, the wire gauge, the

Figure 4. Deformation of the box with hexagonal mesh (Type A). Note the difference in relation to the Type C box, in Figure 5.

type of connections, as well as the quantity and arrangement of the ties (Type B). In the case of Type B welded mesh typologies utilizing 4.00 mm wire, it has been noted that the incorporation of 4.50 mm wire spiral connections facilitates a greater degree of freedom in the displacements of each face, thereby contributing to a moderate deformation behavior. Conversely, Type C, which is characterized by welded mesh made with 4.50 mm gauge wires, features welded eyelet connections and a 6.00 mm locking pin. This configuration exhibits enhanced stiffness, resulting in an increased load capacity and a reduction in deformation (Figure 5).

Table 2 presents a summary of the characteristics of the tested gabion boxes, specifically focusing on their density and the approximated values of Poisson's ratio, Young's modulus

Figure 5. Deformation of the box with coated carbon steel mesh and connection pins (Type C).

Table 2. Results of the unconfined tests (CPs 1 to 10).

CP	Density (kg/m³)	v_{eq}	E_{eq} (MPa)	G_{eq} (MPa)
1	1,846	0.50	4.4	1.5
2	1,878	Data loss from initial loading phase		
3	1,902	0.32	5.7	2.2
4	1,871	0.33	6.6	2.5
5	1,876	0.50	6.3	2.1
6	1,846	0.25	5.8	2.3
7	1,751	0.49	5.0	2.3
8	1,639	0.50	7.0	1.8
9	1,772	0.36	6.2	2.3
10	1,782	0.20	6.2	2.3

Legend: see List of symbols and abbreviations.

and modulus of rigidity. These approximations are derived from classical theory of lasticity. According to Andrade & Possan (2017), these variables and their relationships are applicable only to homogeneous and isotropic materials, which are commonly used to characterize the wire and, in certain instances, the meshes that make up the gabion boxes.

It should be noted that gabions are composite systems (metal mesh, stones, connection accessories, and reinforcements) and have a nonlinear, anisotropic behavior dependent on the resistance of the constituent materials, the internal arrangement of the stones, and the configuration of the meshes and their accessories. According to Santos (2018), who studied hexagonal mesh gabions, the behavior of the gabion element depends on the way and intensity at which horizontal tension is applied to the mesh. Samayoa et al. (2018), based on the studies by Lin et al. (2010) sought to represent the behavior of gabions using an equivalent linear modulus of elasticity, considering situations under low levels of compressive stress. In this same perspective, the term "equivalent parameters" was adopted in the present study for the presentation of the experimentally obtained results, determined in the initial phase of vertical compression loads, with the behavior of the composite system practically linear in terms of stress versus strain.

To generate graphs illustrating the behaviors observed in both the confined and unconfined tests, the average vertical displacements of the boxes were used. These displacements were calculated as the mean of the four sensors strategically positioned on the tops of the boxes. Furthermore, it took into account the measured displacements of the instrumented level that exhibited the most significant deformations on the free front face of the gabion boxes. The values of the equivalent variables were derived graphically and subsequently integrated using Equation 1.

$$G_{eq} = \frac{E_{eq}}{2*\left(1+\nu_{eq}\right)} \tag{1}$$

where: G_{eq} = equivalent to the modulus of rigidity of the structure; E_{eq} = equivalent to the secant modulus of elasticity (initial loading phase); υ_{eq} = equivalent to the Poisson coefficient (ratio between horizontal and vertical strains).

Figures 6 to 8 illustrate the stress-strain behavior observed in the tests conducted on boxes CP1, CP3 to CP10, excluding box CP2, which experienced partial data loss due to an acquisition system failure. The comparative analysis of the graphs, all presented on the same scale, indicates that hexagonal mesh gabions exhibit the greatest deformations when compared to the other types at similar stress levels. Additionally, it is important to note that the horizontal deformations are less pronounced than the vertical deformations. This difference is attributed to the locking systems of the boxes, which employ various types and positioning of tie rods.

5.2 Confined tests

Studies have demonstrated that confinement allows for higher loads, regardless of the types of mesh used in the boxes. Additionally, confinement reduces both vertical and horizontal displacements of the free face when compared to measurements taken from boxes with all side faces free at the same loading levels.

The confined trials, although conducted in fewer numbers than the non-confined trials, still allowed for the determination of the equivalent variables of the boxes. It is important to note that the calculated parameter for Young's equivalent modulus (E_{eq}) is associated with low levels of deformation (less than 4% vertical deformation) and loads of up to 300 kPa. These conditions are typically encountered in projects involving gravity walls and reinforced soil front walls. Furthermore, the laboratory tests achieved loads significantly higher than those typically experienced by the gabion in field conditions, particularly regarding vertical stresses due to its weight.

Table 3 summarizes the results of the tests conducted in the confined boxes CP 1A to 5A, as illustrated in Figures 9 and 10. The stress-strain curves from these tests are represented in Figure 11 and 12.

5.3 Analysis of the results

The results from the series of tests indicated that the parameter equivalent to the secant Young's Modulus ranged between 4.4 and 9.7 MPa, with the highest values observed in the confined tests using welded mesh gabions. These values are associated with low deformations in both

Table 3. Results of the confined tests (CPs 1A to 5A).

CP	Density (kg/m³)	υ_{eq}	E_{eq} (MPa)	G_{eq} (GPa)
1A	1,872	0.42	7.2	2.5
2A	1,938	0.33	9.3	3.5
3A	2,013	0.17	8.7	3.7
4A	1,998	0.46	9.7	3.3
5A	2,001	0.50	8.7	2.9

Legend: see List of symbols and abbreviations.

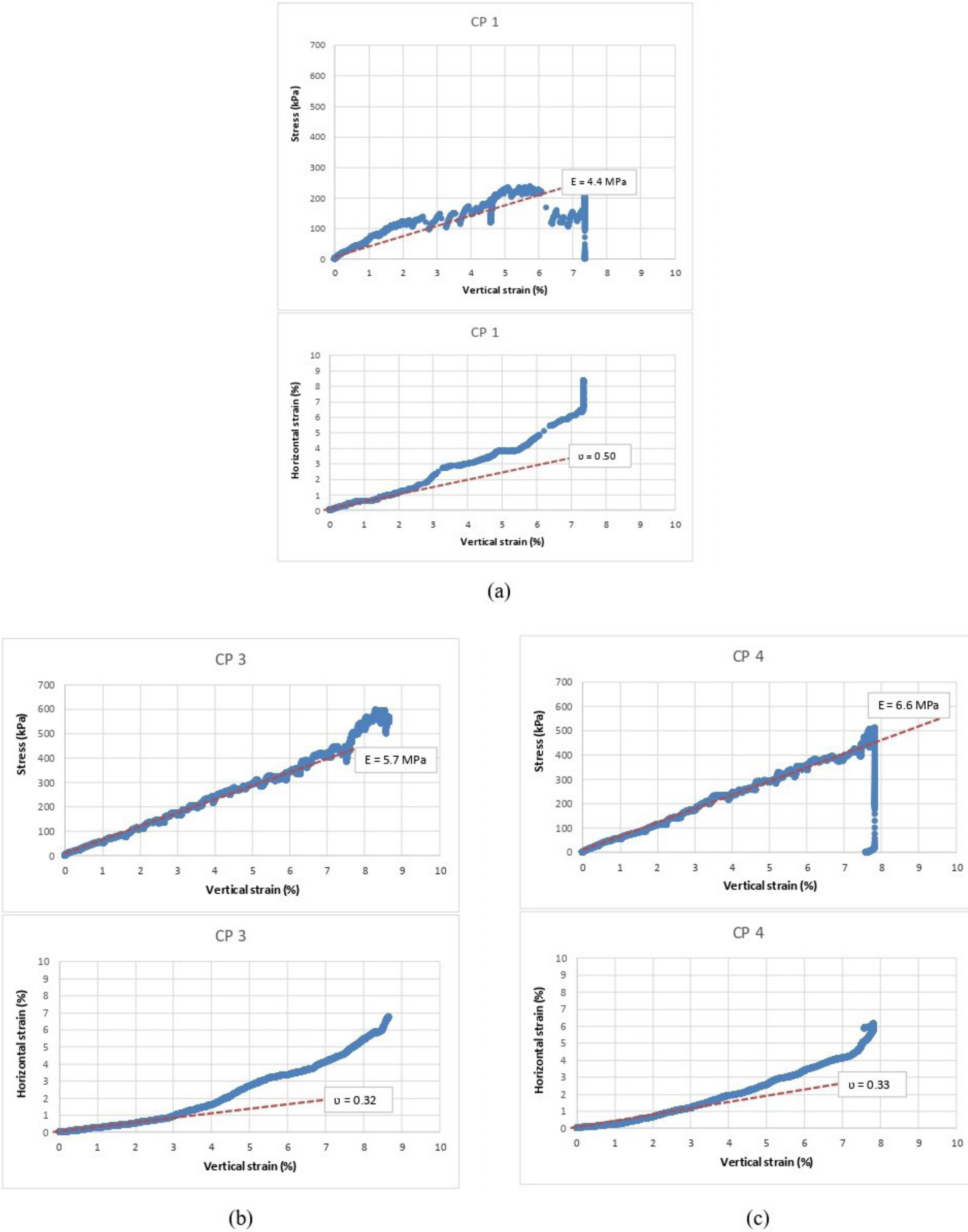

Figure 6. Stress strain behavior - unconfined tests results of: (a) CP 1 box; (b) CP 3 box; and (c) CP 4 box.

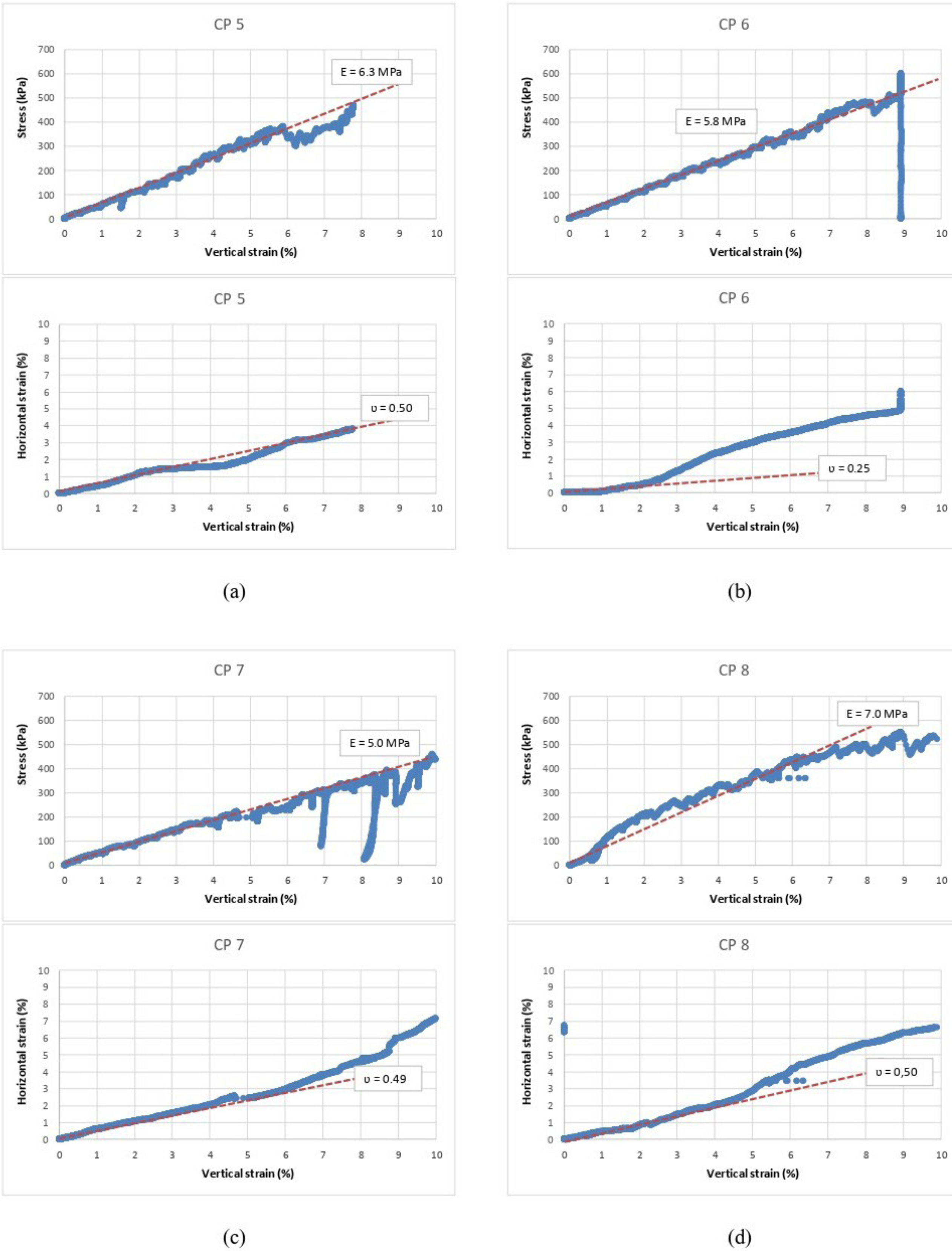

Figure 7. Stress strain behavior - unconfined tests results of: (a) CP 5 box; (b) CP 6 box; (c) CP 7 box; (d) CP 8 box.

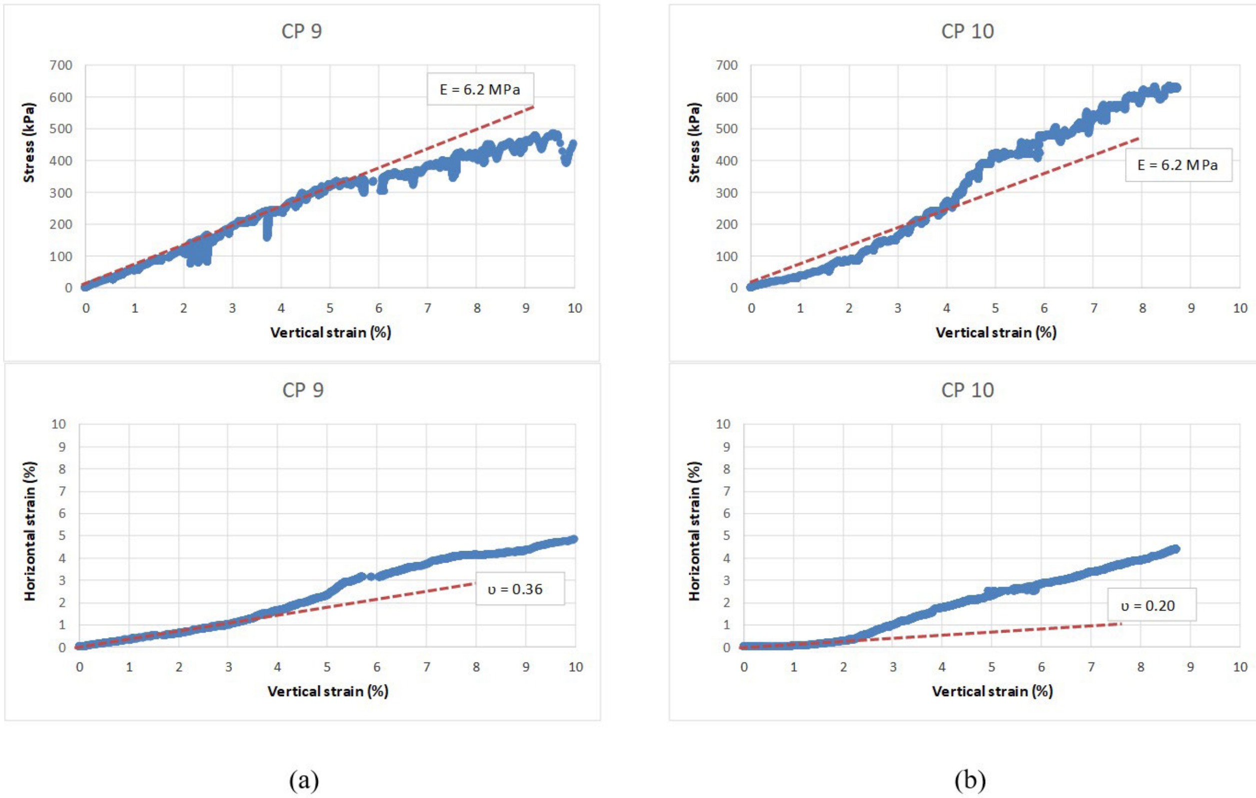

Figure 8. Stress strain behavior - unconfined tests results of: (a) CP 9 box; (b) CP 10 box.

Figure 9. Test in box CP 2A.

Figure 10. Face deformation of CP 2A.

the vertical and horizontal directions, remaining below 10%. They reflect the behavior of the system composed of mesh, stones, and wire components. The equivalent secant modulus may yield higher values due to the configuration of the stress curves, which increase as the core of the stone fill experiences progressive stress fractures. This situation increasingly necessitates external wire mesh for containment. However, it is important to note that this study did not account for the potential rupture of the filling elements under the imposed loads. Future studies utilizing discrete element numerical modeling could provide a more accurate assessment of the behavior of the filling materials.

It's important to note that the number of tests conducted is relatively small, especially for double-twist hexagonal mesh gabions, which already have a significant amount of reference data available in the literature. However, the consistency and repeatability of the data from various types of welded mesh gabions suggest that the obtained results are representative of similar structures.

By way of numerical comparison, the work of Lin et al. (2010) proposed a stress-strain relationship for a single component of a hexagonal mesh box gabion, tested under various lateral confinement conditions. The authors considered a limited compressive stress range of 200 to 1,650 kPa and concluded that the relationship can be assumed to be linear. The equivalent tangent Young's modulus ranged from 0.8 to 3.0 MPa under unconfined conditions. In the presence of confinement and with stresses ranging from 400 to 3,380 kPa, the same parameter increased to a range of 2.0 to 6.0 MPa.

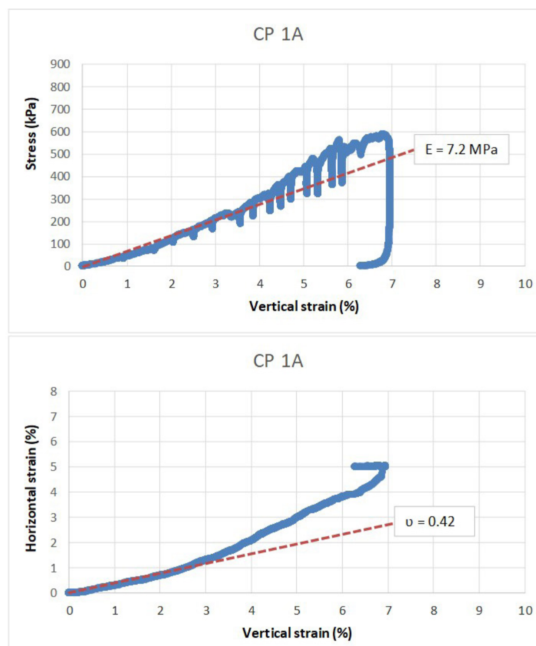

Figure 11. Stress strain behavior – confined test of CP 1A.

In conclusion, while laboratory tests and numerical models may not fully replicate all field conditions, they provide valuable insights into the impact of various parameters on the mechanical behavior of the mesh (Baek et al., 2020) and the gabions as a composite system.

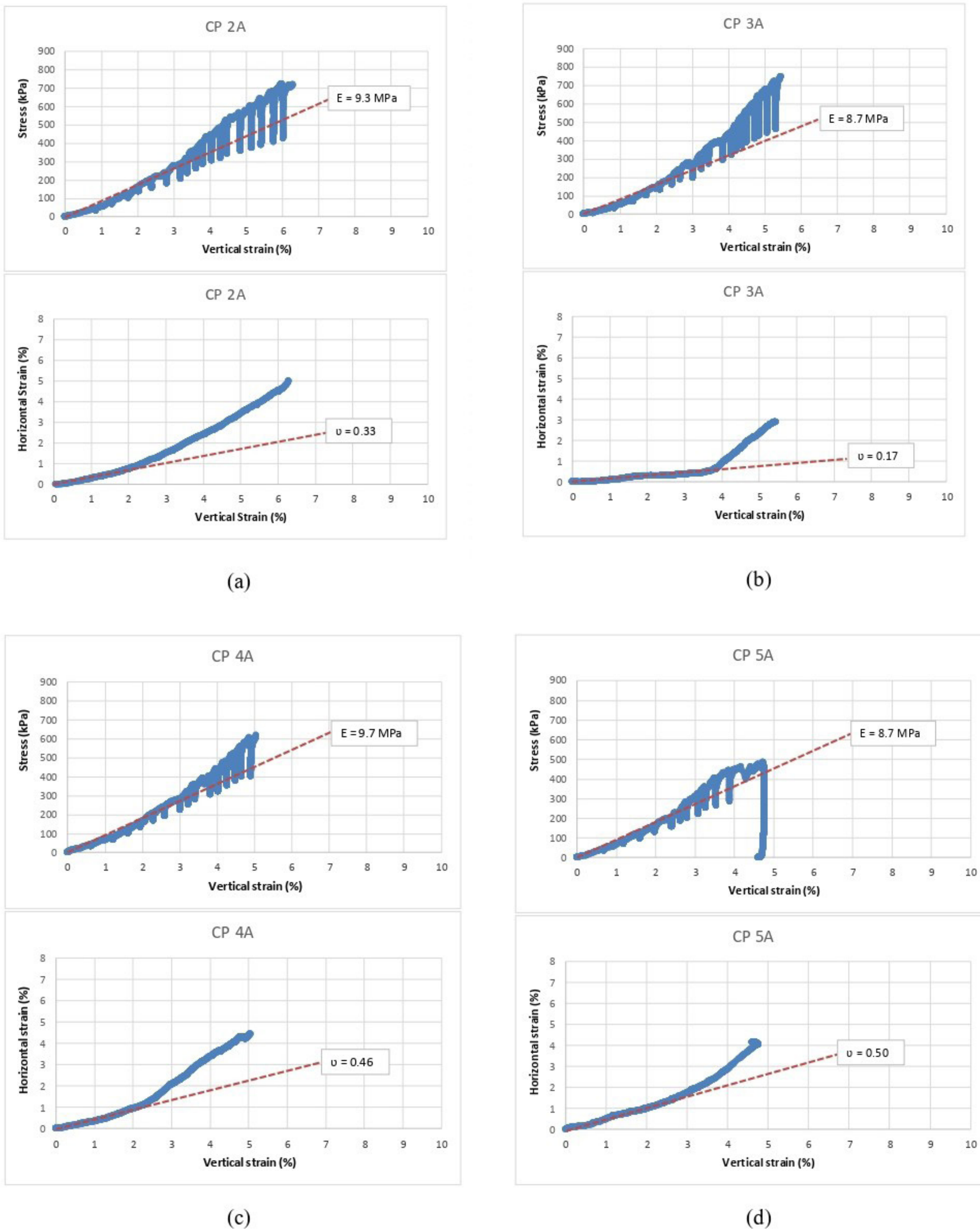

Figure 12. Stress strain behavior – confined tests results of: (a) CP 2A box; (b) CP 3A box; (c) CP 4A box; (d) CP 5A box.

6. Conclusions

Overall, the tests showed that gabion boxes made with Type B and Type C wires, constructed from carbon steel wire coated with ZnAl alloy with higher tensile strength (600 MPa), exhibit greater resistance regardless of the number of tie rods used. In terms of deformability, the Type A mesh, which is hexagonal and features a double twist, regular tensile strength (400 MPa), demonstrates a higher capacity to absorb significant deformations.

It was observed that some wires broke in areas thermally affected by the welds, particularly near the edges. Conversely, in regions close to the tie rod attachment, no breakage occurred during loading in the unconfined condition. In terms of stress and deformation behavior, the increased stiffness of the welded mesh, combined with the use of prefabricated connections and tie rods of the same dimension, results in dimensional uniformity and reduced deformation of the mesh surfaces.

The proposal to utilize parameters typically associated with homogeneous and isotropic materials is valid for low levels of loads and related deformations, with values that closely align with those found in specific literature. However, it is strongly recommended to conduct additional tests that consider various filling materials and new designs for manufacturing the boxes. This will help create a database that enables a statistical analysis of the results.

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Declaration of interest

The authors have no conflicts of interest to declare. All co-authors have observed and affirmed the contents of the paper and there is no financial interest to report.

Authors' contributions

Gisleine Coelho de Campos: data curation, methodology, formal analysis, writing – review & editing. Rafael da Fonseca: conceptualization, data curation, formal analysis, writing – review & editing. Gelmo Chiari Costa: formal analysis, funding acquisition, methodology, writing – review & editing.

Data availability

The datasets generated analyzed in the course of the current study are available from the corresponding author upon request.

Declaration of use of generative artificial intelligence

This work was prepared without the assistance of any generative artificial intelligence (GenAI) tools or services. All aspects of the manuscript were developed solely by the authors, who take full responsibility for the content of this publication.

List of symbols and abbreviations

G_{eq} equivalent to the modulus of rigidity of the structure

E_{eq} equivalent to the secant modulus of elasticity (initial loading phase)

v_{eq} equivalent to the Poisson coefficient (ratio between horizontal and vertical strains)

References

ABNT NBR 10514. (1988). *Redes de aço com malha hexagonal de dupla torção, para fabricação de gabiões.* ABNT - Associação Brasileira de Normas Técnicas, Rio de Janeiro, RJ.

ABNT NBR 8964. (2024). *Arames de aço de baixo teor de carbono, revestidos, para gabiões e demais produtos fabricados com malha de dupla torção.* ABNT - Associação Brasileira de Normas Técnicas, Rio de Janeiro, RJ.

Andrade, J.J.O., & Possan, E. (2017). Propriedades físicas e mecânicas dos materiais. In G. C. Isaia (Ed.), *Materiais de construção civil e princípios de Ciência e Engenharia de Materiais* (3. ed., Vol. 1, pp. 120-145). São Paulo: IBRACON.

ASTM A 974-97. (2021). *Standard specification for welded wire fabric gabions and gabion mattresses (metallic-coated or polyvinyl chloride (PVC) coated).* ASTM International, West Conshohocken, PA.

Baek, B., Karampinos, E., & Hadjigeorgiou, J. (2020). Understanding the impact of test configuration on welded wire mesh laboratory test results. *Rock Mechanics and Rock Engineering*, 53(11), 4873-4892. https://doi.org/10.1007/s00603-020-02198-w.

DIN EN 10223-8. (2013). *Steel wire and wire products for fencing and netting – part 8: welded mesh gabion products.* Deutsches Institut für Normung, Berlin.

Karampinos, E., Baek, B., & Hadjigeorgiou, J. (2018). *Discrete element modelling of a laboratory static test on welded wire mesh*. In Y. Potvin, & J. Jakubec (Eds.), *Caving 2018: Proceedings of the Fourth International Symposium on Block and Sublevel Caving* (pp. 735-746). Crawley: Australian Centre for Geomechanics. https://doi.org/10.36487/ACG_rep/1815_57_Hadjigeorgiou.

Lin, D.G., Lin, Y.H., & Yu, F.C. (2010). Deformation analyses of gabion structures. In *Interpraevent 2010: International Symposium in Pacific Rim* (pp. 512-526), Taipei, Taiwan. International Research Society.

Rocha, C. V. (2025). *Avaliação do desempenho de gabiões eletrossoldados com diferentes materiais de preenchimento para aplicações em infraestrutura sustentável* [Master's dissertation]. Universidade Nove de Julho.

Samayoa, J., Baraccani, S., Pieraccini, S., & Silvestri, S. (2018). Seismic behaviour of one-storey gabion-box walls buildings. *Frontiers in Built Environment*, 4, 7. https://doi.org/10.3389/fbuil.2018.00007.

Santos, J. R. P. J. (2018). *Gabiões e estruturas de arrimo: análise teórico-numérico-experimental do comportamento mecânico* [Doctoral thesis]. Universidade Estadual de Campinas.