Journal of Mining and Environment (JME) Vol. 13, No. 4, 2022, 1139-1157

Shahrood University of Technology

Journal of Mining and Environment (JME)

Journal homepage: www.jme.shahroodut.ac.ir

Iranian Society of Mining Engineering (IRSME)

Preparation of Heterogeneous Rock-Like Samples Containing Non-Persistent Notch; Different Layout

Rahim Mortezaei[1], Seyed Davoud Mohammadi[1]*, and Vahab Sarfarazi[2]

1. Department of Geology, Bu-Ali Sina University, Hamedan, Iran
2. Department of Mining Engineering, Hamedan University of Technology, Hamedan, Iran

Article Info

Received 5 October 2022
Received in Revised form 14 October 2022
Accepted 28 October 2022
Published online 28 October 2022

DOI:10.22044/jme.2022.12318.2235

Keywords

Plaster
Sampling molds
Heterogeneous samples
Laboratory model

Abstract

One of the most important tasks in conducting a laboratory research work is how to make the samples. The purpose of this research work is to create heterogeneous rock-like samples containing non-persistent notches. Regarding that, the molds with dimensions of 250 mm x 200 mm x 50 mm are made. A mixture of plaster and water with different mixing percentages is used to make the heterogeneous samples. Various techniques are also employed to create non-persistent notches on the samples. One of the methods to create a notch is to insert an aluminum blade into the groove of the mold, and finally, remove it after the plaster slurry has hardened. Due to the displacement of the blade and its tilting during slurring, the notches are out of the vertical position. In addition to the mentioned method, other methods such as water jet, cutting by thread, cutting by diamond wire cutting, cutting by rotary saw, and using hand saw are applied. Finally, using a hand saw to create a notch on the samples is chosen as the best method..

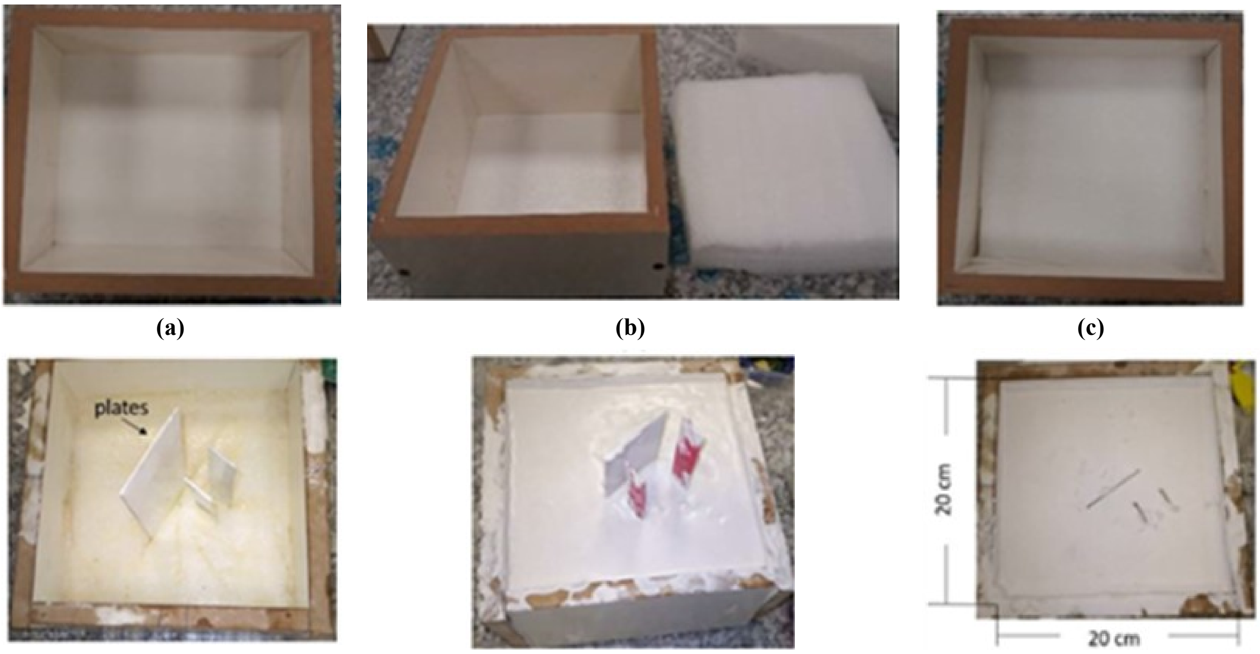
1. Introduction

Various geological factors and tectonic conditions of the region have a great impact on the stability of rock engineering projects. Among these factors, we can refer to the uniaxial compressive strength, tensile strength, deformability, abrasiveness of the rock, presence of quartz veins and other abrasive minerals, faults and shear zones, degree of crushing and e type of joints, and dip and direction of the joints. Since rocks appear in nature with different characteristics, the existence of heterogeneous and anisotropic rocks with irregular joints can affect the mechanical properties of rock (Figure 1).

In order to study the behavior of these rock masses under different loading condition in the laboratory, it is necessary to prepare heterogeneous rock like samples containing non-persistent notch. In the last decade, various research works have been tried to make a physical sample. Sarfarazi *et al*. [2] have used plaster samples to study the failure behavior of F-shaped non-persistent notches under uniaxial load. To make non-persistent notches, they placed steel plates with a thickness of 1 mm in plastic foam with a thickness of 50 mm (Figure 2).

✉ Corresponding author: d.mohammadi@basu.ac.ir (S.D. Mohammadi)

Figure 1. Heterogeneous rock mass containing irregular joints [1].



(a) (b) (c)

(d) (e) (f)

Figure 2. (a) Frame with dimensions of 200 mm x 200 mm x 100 mm (b) a special plastic foam with dimensions of 200 mm x 200 mm x 50 mm placed in the frame (c) mold containing plastic foam (d) placement of the blade inside the plastic foam (e) pouring plaster slurry inside the mold, and (f) aluminum blade removed from the mold [2].

Amini *et al*. [3] have used a mold with dimensions of 120 mm x 150 x 50 mm to study the effect of non-persistent notch sets on the failure behavior of rock like samples. To make non-persistent notches, steel plates were placed with a thickness of 1 mm in plastic foam with a thickness of 50 mm (Figure 3).

Fu *et al*. [4] have used cylindrical mold to make disk samples containing a central crack. To create a notch, an aluminum plate was placed in the center of the cylinder inside the plastic foam. Also to make a semi-circular sample with an edge notch, a circular cylinder was divided into two parts, and an aluminum plate was placed inside the plastic foam (Figure 4).

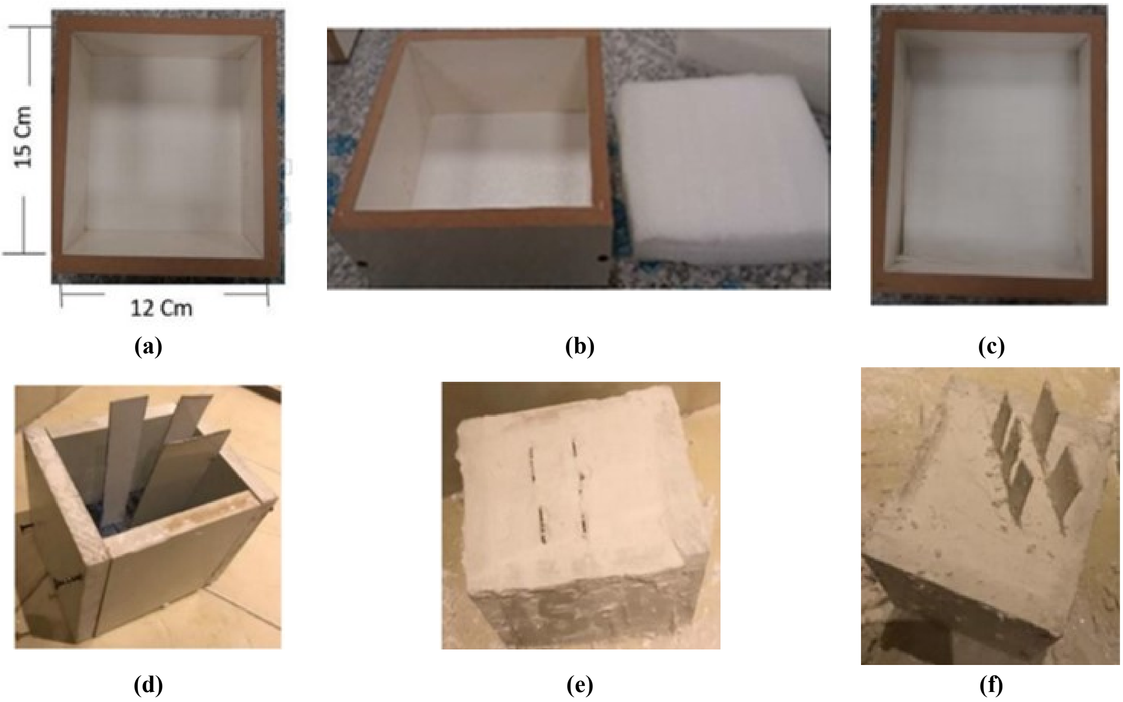


Figure 3. (a) Frame with dimensions of 120 mm x 150 mm x 100 mm (b) a special plastic foam with dimensions of 150 mm x 120 mm x 50 mm was placed in the frame (c) mold containing plastic foam (d) placement of the sheet inside the plastic foam (e) gypsum slurry inside the mold, and (f) aluminum sheet is removed from the mold [3].

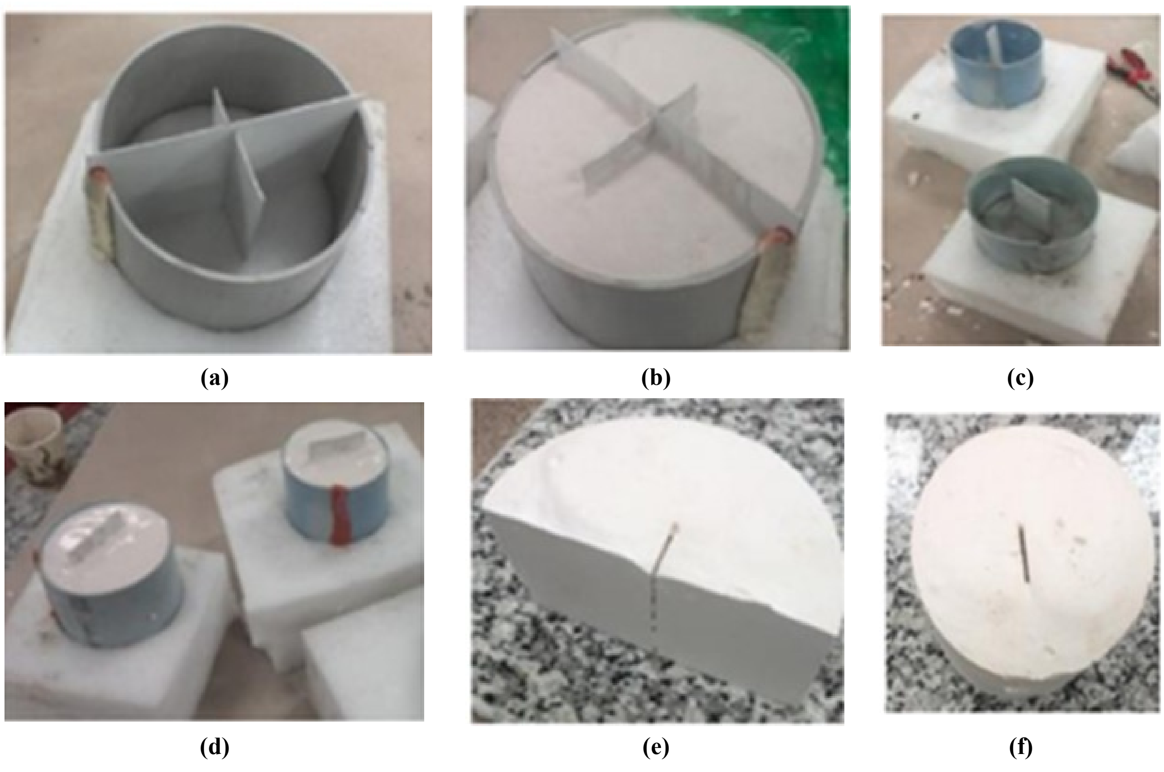


Figure 4. (a) Cylindrical mold with a diameter of 120 mm and a height of 100 mm (to make a semi-circular sample), a special plastic foam placed in the frame, and the sheet placed inside the plastic foam, (b) pouring plaster slurry inside the mold, (c) a cylindrical mold with a diameter of 120 mm and a height of 100 mm (circular sample), a special plastic foam placed in the frame, the blade placed inside the plastic foam, (d) pouring plaster slurry inside the mold, (e) a semi-circular sample containing an edge notch, and (f) a circular sample containing an enclosed notch [4].

Bagher Shemirani *et al*. [5] have studied the interaction between the concrete-plaster interface with a central notch. They prepared semi-circles of concrete and plaster, and then connected them by using a kind of stone glue to create an artificial joint (notch) with the desired dimensions at the interface. The notch was free of glue (Figure 5).

To study the mechanical behavior of the samples containing vertical non-persistent notch under uniaxial compression, Fu *et al*. [6] have made cubic samples with dimensions of 100 mm x 100 mm x 100 mm containing vertical notches. In order to create a notch, grooves were created at the top and bottom of the mold, and aluminum plates were placed in these grooves leading to the creation of a notch (Figure 6).

Shakeri *et al*. [7] have used a plexiglas cylindrical mold with a grooved end to make a sample of a disk containing multiple non-persistent notches. To create a notch, aluminum blades were placed in these grooves (Figure 7).

(a) (b) (c)

Figure 5. (a) Cylindrical mold with a diameter of 120 mm and a height of 100 mm (semi-circular sample), a special plastic foam placed in the frame, placing the sheet inside the plastic foam, pouring plaster slurry inside the mold, (b) semi-cylindrical samples of plaster and concrete separately, and (c) connecting the samples to each other by glue and creating an intermediate notch [5].

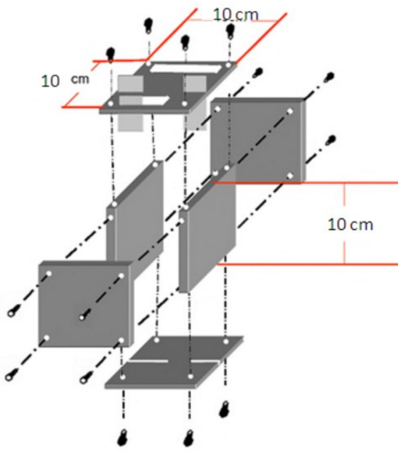


Figure 6. Schematic view of a notched cube mold with dimensions of 100 mm x 100 mm x 100 mm [6].

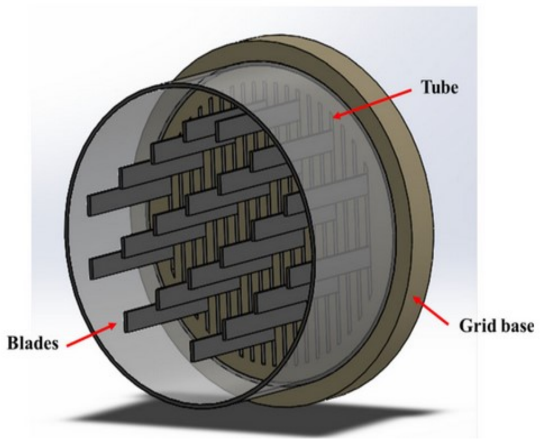
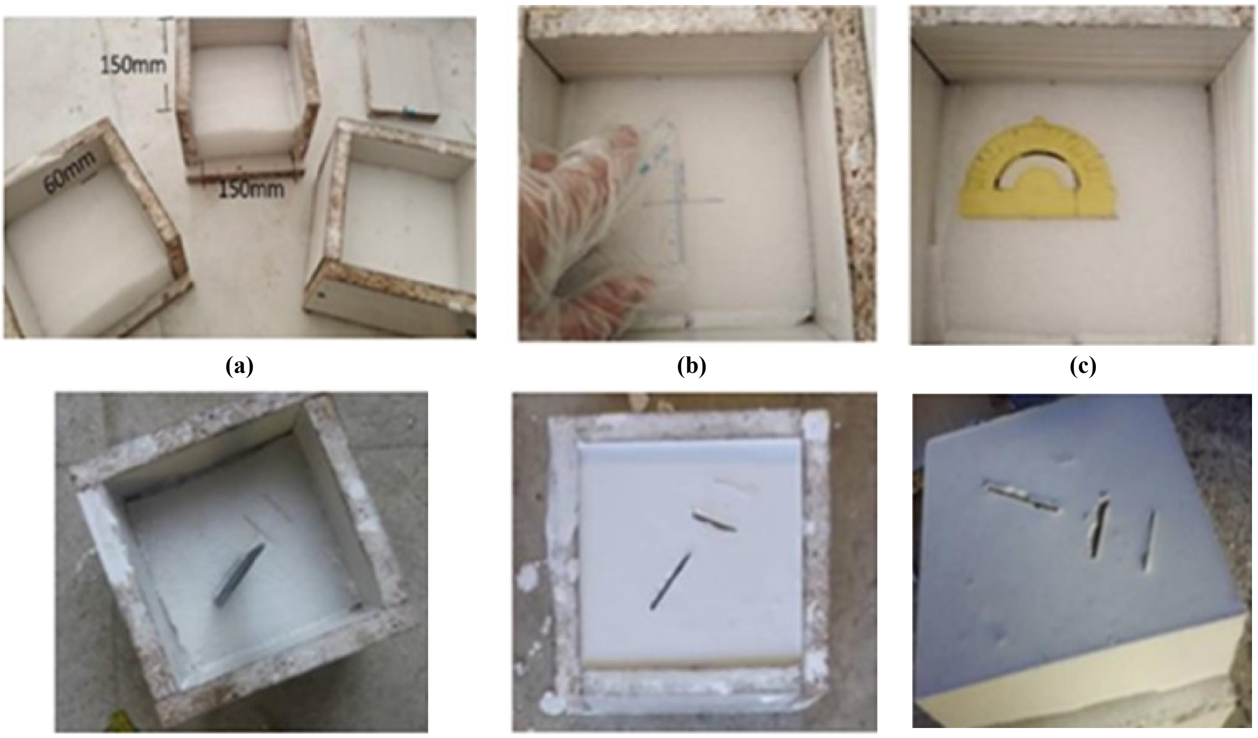


Figure 7. Cylindrical plexiglas mold [7].

Sarfarazi *et al*. [8], to investigate the influence of the angle and number of T-shaped non-persistent notch on the compressive behavior of the rock like sample, have conducted a uniaxial compression test on plaster samples with dimensions of 150 mm x 150 mm x 60 mm. To make a non-persistent notch, steel plates were placed with a thickness of 1 mm in plastic foam with a thickness of 50 mm (Figure 8).



(a) (b) (c)

(d) (e) (f)

Figure 8. (a) Mold with dimensions of 150 mm x 150 mm x 60 mm (b) a special plastic foam with dimensions of 150 mm x 150 mm x 50 mm placed in the frame (c) mold containing plastic foam (d) placement of inside the plastic foam (e) plaster slurrying inside the mold, and (f) aluminum blade removed from the mold [8].

To study the shear behavior of heterogeneous samples with a layer of plaster and concrete containing non-persistent notch, Fu *et al*. [9] firstly, divided the mold with dimensions of 200 mm x 200 mm x 100 mm into two parts using a sheet. Then two aluminum blade were placed inside the plastic foam to create two non-persistent notches. Concrete and plaster containing an edge notch have been made and then connected to each other by glue (Figure 9).

Fu *et al*. [10] have studied the interaction between the concrete-plaster interface and edge notch in a three-point bending test. First they prepared quarter-circle samples of plaster and concrete, and then they connected the samples by stone glue in such a way that an edge notch with an ideal depth has been created (Figure 10).

Sarfarazi *et al*. [11], to study the interaction of holes and cracks under uniaxial load, made plaster samples with dimensions of 150 mm x 150 mm x 150 mm containing joints and holes. They put aluminum sheets and circular cylinders inside the plastic foam to create notches and holes (Figure 11).

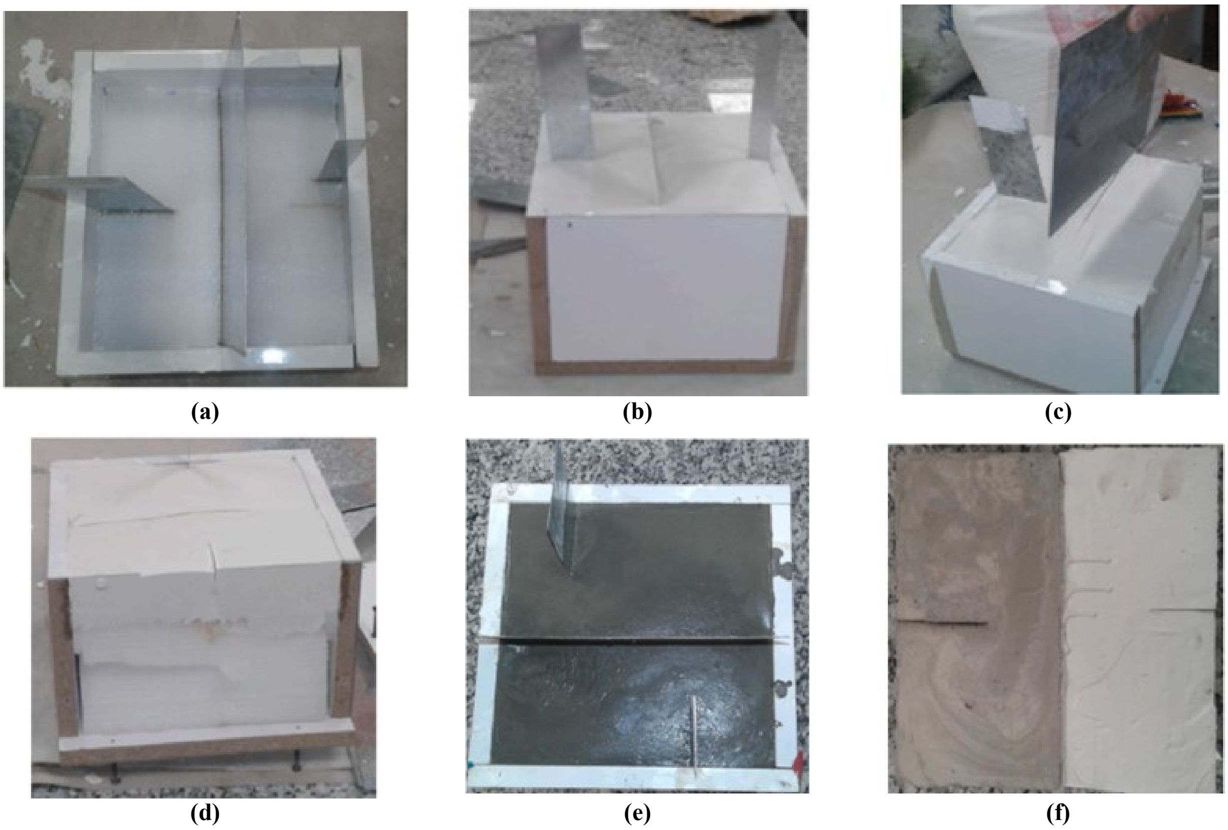


Figure 9. (a) Mold with dimensions of 200 mm x 200 mm x 100 mm, a special plastic foam placed in the frame, placing the sheet inside the plastic foam, (b) plaster slurrying inside the mold, (c) removing the sheet (d) plaster sample containing edge notch, (e) concrete slurring inside the mold, and f) connecting the plaster and concrete samples by glue to each other [9].

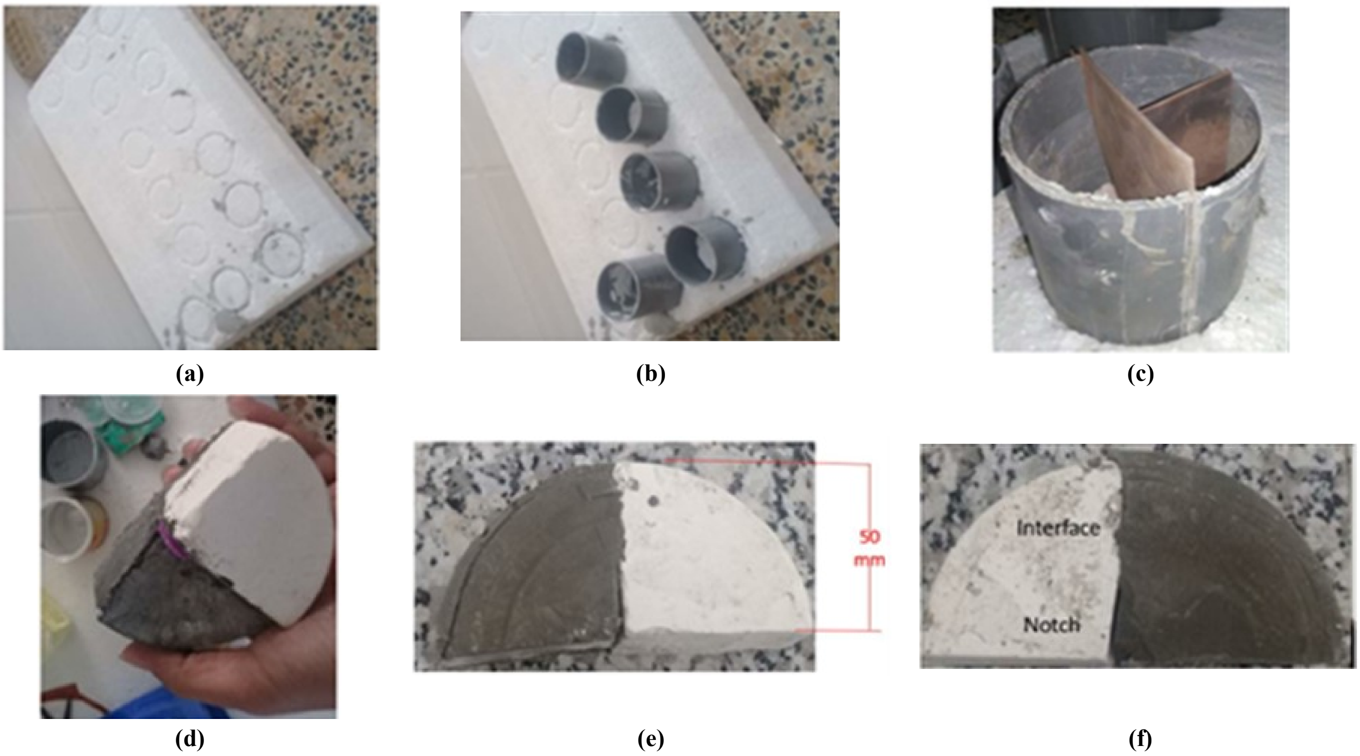
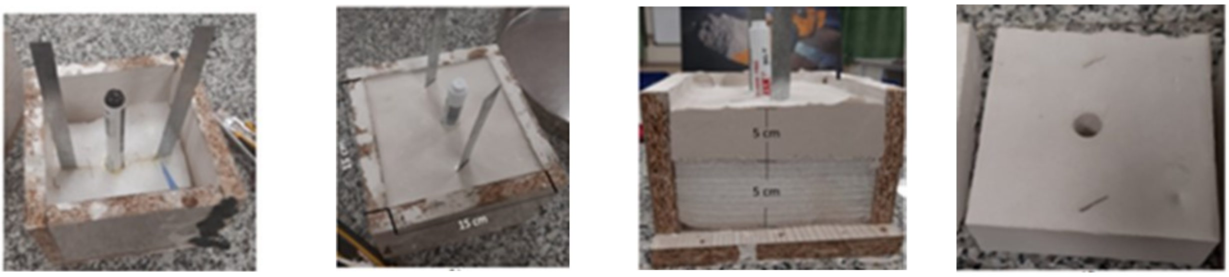


Figure 10. (a) Plastic foam, (b) cylindrical mold with a thickness of 100 mm and a diameter of 150 mm, (c) aluminum sheet located in plastic foam, (d) preparation of the concrete and plaster samples, separately, (e and (f) connecting the plaster and concrete samples by glue [10].



(a) (b) (c) (d)

Figure 11. (a) Frame dimensions 150 mm x 150 mm x 150 mm. A plastic fiber with dimensions of 150 mm x 150 mm x 100 mm was placed in the frame, the sheet inside the plastic foam, (b) plaster slurry inside the mold, (c) side-view of the sample, and (d) a sample consisting of cavity and joint [11].

Yang *et al*. [12] have used the template in Figure 2 to study the failure behavior of brittle rock like samples containing multi-non-persistent joints under uniaxial compression. The used mold had grooves at the top and bottom where aluminum blades placed in the grooves and several joints have been created (Figure 12).

Haeri *et al*. [13] have prepared plaster samples with dimensions of 150 mm x 150 mm x 50 mm to study the behavior of non-persistent joints under punch shearing (Figure 13). The geometry of the sample and non-persistent joints have been created by placing wooden timbers and aluminum blades inside the plastic foam.

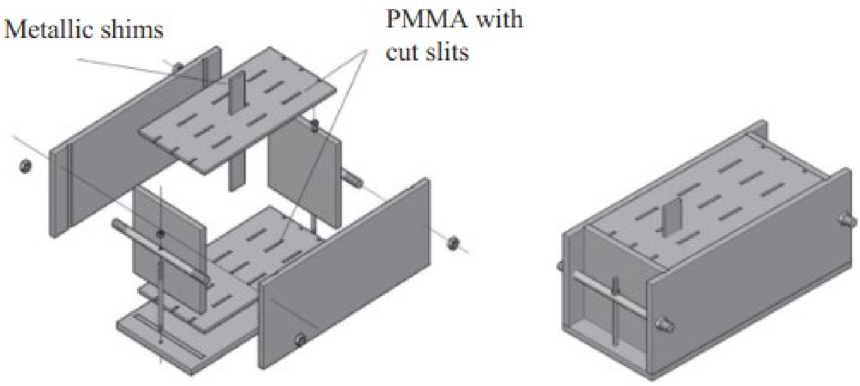


Figure 12. Mold used to make brittle rock-like samples containing multi-non-persistent joints [12].

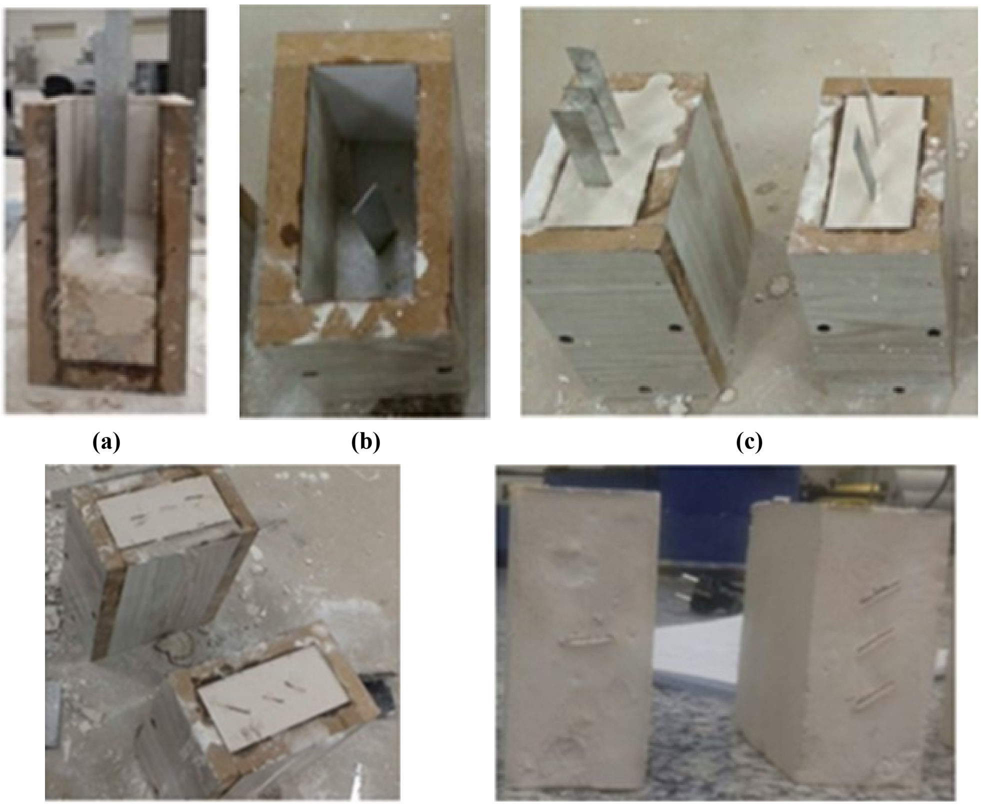
(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 13. (a) Mold with dimensions 150 mm x 150 mm x 50 mm , (b) plastic foam inside the mold, (c) placement of timber inside the foam, (d) placement of aluminum blade inside the foam, (e) plaster slurrying inside the mold, (g) removal blade from the mold, and (h) sample containing non-persistent joint [13].

Haeri *et al*. [14] have prepared mortar samples with dimensions of 100 mm x 100 mm x 50 mm to study the behavior of three non-persistent notches under uniaxial compression (Figure 14). Non-persistent notches were created by placing aluminum blades inside plastic foam.

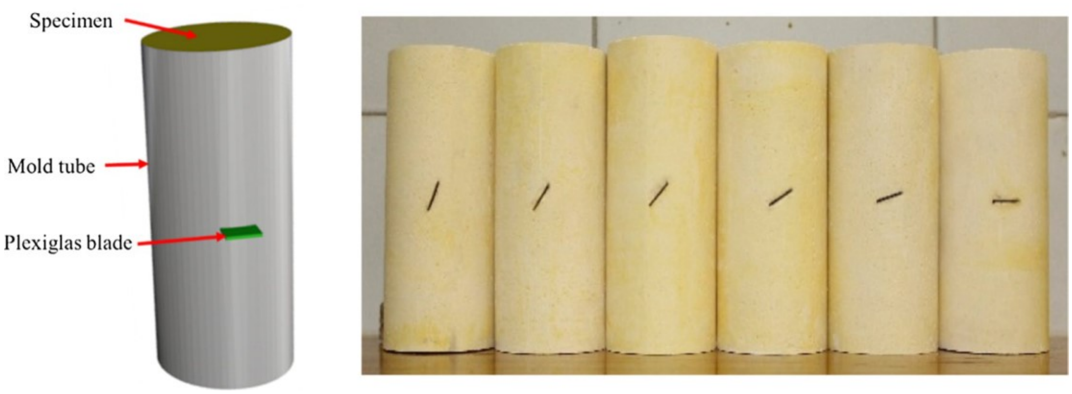
Asadizadeh *et al*. [15] have performed a uniaxial test on rock like cylindrical samples containing a central flaw (Figure 15). By placing a plexiglas blade in the groove which located in the plastic cylinder, a non-persistent flaw has been created.



(a) (b) (c)

(d) (e)

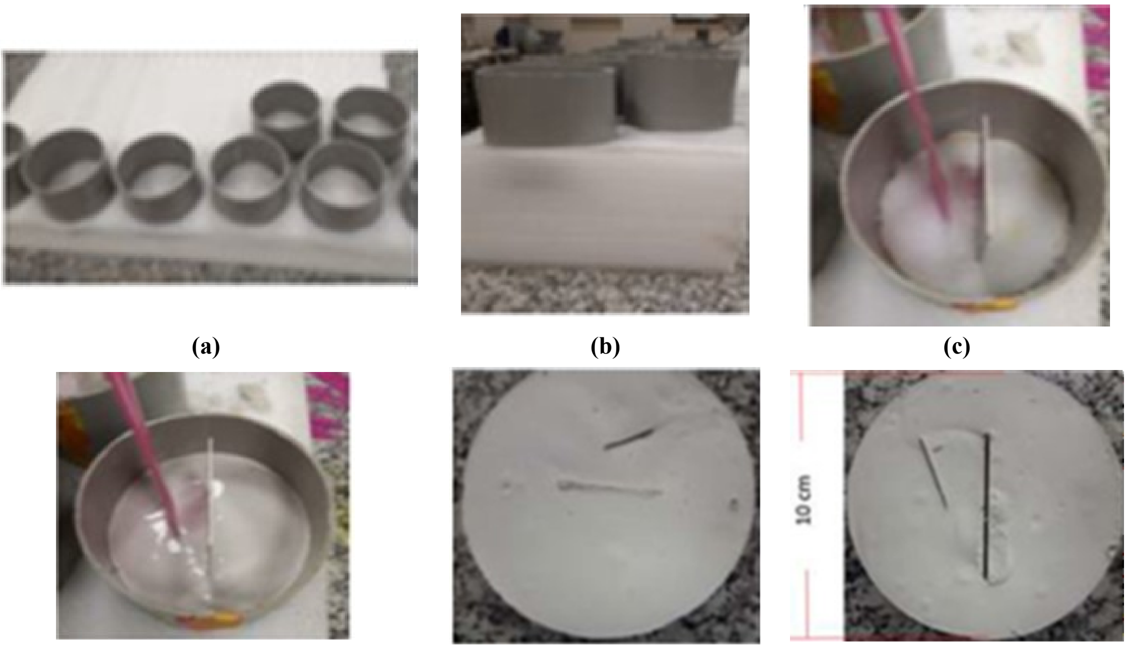
Figure 14. (a) Mold with dimensions of 100 mm x 100 mm x 50 mm, (b) plastic foam with dimensions of 100 mm x 50 mm x 50 mm inside the mold, (c) aluminum sheet inside the plastic foam, mortar slurry inside the mold, (d) removal of the sheet Aluminum from the mold, and (e) sample containing non-continuous joints [14].



[redacted] [redacted]

Figure 15. (a) Grooved cylindrical mold (b) plaster samples with a central flaw [15].

Sarfarazi *et al*. [16] have used plaster cylindrical specimens with a diameter of 100 mm and a thickness of 40 mm to study the failure behavior of y-shaped joints under indirect tension. To make non persistent joints, steel plates with a thickness of 1 mm were placed in plastic foam with a thickness of 50 mm (Figure 16).



(a) (b) (c)

(d) (d) (f)

Figure 16. (a) Mold with a diameter of 100 mm and a thickness of 40 mm (b) a special plastic foam placed in the frame (c) placement of the sheet inside the plastic foam (d) plaster slurrying inside the mold (e) aluminum sheet removed from the mold, and (f) sample containing a y-shape joint [16].

To measure the fracture toughness of concrete with a new test, Zhou *et al*. [17] have made semi-ring samples containing edge cracks. To make non-persistent joints, steel plates with a thickness of 1 mm were placed in a plastic foam with a thickness of 50 mm (Figure 17).

Asadizadeh *et al*. [18] have used metal molds with dimensions of 200 mm x 200 mm x 50 mm to study the shear behavior of rock like samples containing irregular closed joints. To create closed joints, the desired profiles have been placed in the mold and restrained from the top (Figure 18).

Figure 17. Mold used to make a semi-ring sample containing an edge joint [17].

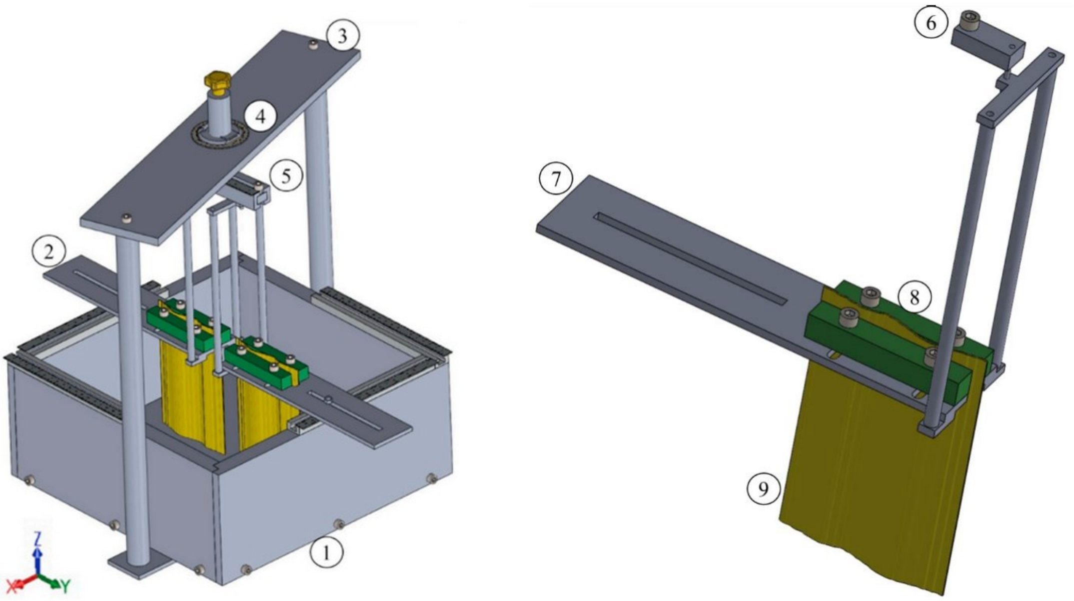
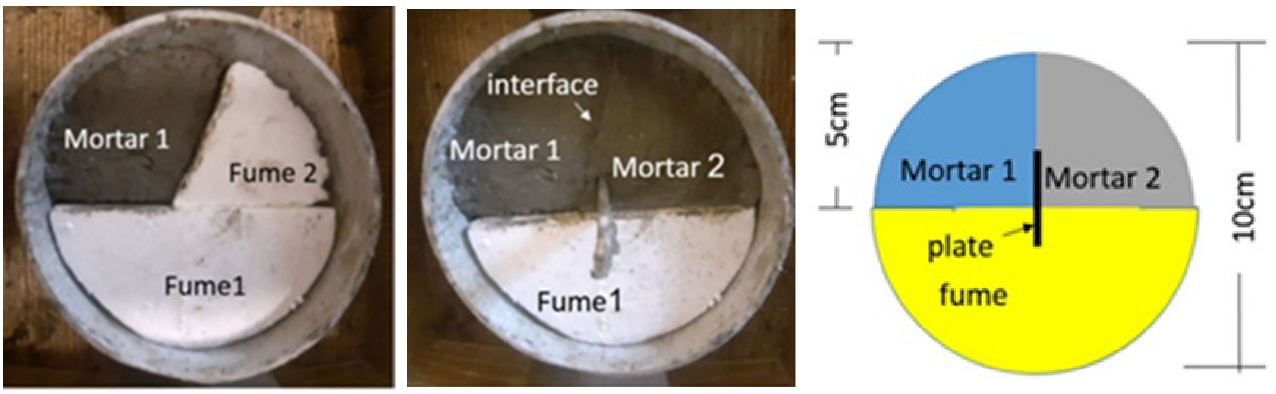


Figure 18. Schematic views of the mold designed for casting specimens containing artificial joints: (1) box for casting the specimen, (2) sliding rail for angle control, (3) steel rod for connecting the upper and lower platforms, (4) conveyor for angle control, (5) piece T to control the distance of the joint, (6) L piece head, (7) L piece sliding rail to control its movement along the X and Y direction, (8) JRC sheet holder, and (9) JRC sheet [18].

Fu *et al*. [19], to study the interaction of concrete-concrete interface and edge notch under three-point bending, have prepared quarter circles of concrete connected to each other. Also to create a joint at the edge of the sample, an aluminum blade was placed in 50 mm foam in thickness (Figure 19).

Sarfarazi *et al*. [20] have prepared rock-like pillar samples with dimensions of 150 mm x150 mm x 50 mm to study the mechanical behavior of cavity, semi-cavity, and non-persistent joints under uniaxial compression (Figure 7). Non-persistent joints, cavity and semi-cavity, were created by placing aluminum blades, cylinders, and semi-cylinders in plastic foam with a thickness of 50 mm (Figure 20).



(a) (b) (c)

Figure 19. (a) A cylindrical mold with a diameter of 100 mm and a thickness of 40 mm, placing foam 1 and foam 2 in two parts of the mold and pouring the slurry into the third part (b) placing the blade inside foam 1 and removing foam 2 and pouring the slurry in the second part, and (c) arrangement of the blade and the junction of the different slurries [19].

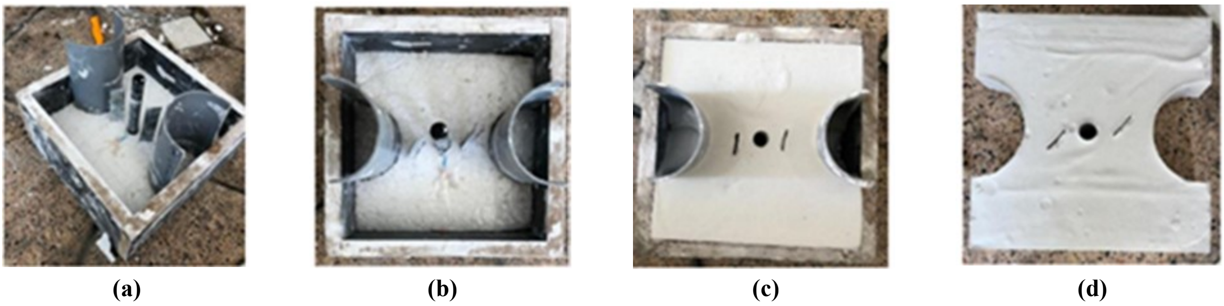


Figure 20. (a) and (b) Mold with dimensions of 150 mm x 150 mm x 50 mm, special plastic foam with dimensions of 150 mm x 150 mm x 50 mm in the frame, plastic cylinders and aluminum blade inside the foam (c) plaster slurry inside the mold, and (d) aluminum blade removed from the mold [20].

Yang *et al*. [21] have prepared rock blocks with dimensions of 160 mm x 80 mm to study the mechanical behavior of a sandstone sample containing three non-persistent open fissures under uniaxial compression. Non-persistent fissures were created by using water jet in the samples (Figure 21).

Shaunik and Singh [22] have investigated the crack growth behavior of concrete samples containing one, two, and three non-persistent joints under uniaxial compression. To create non-persistent joints, they placed aluminum blades in the mold, and restrained them from above and below (Figure 22).

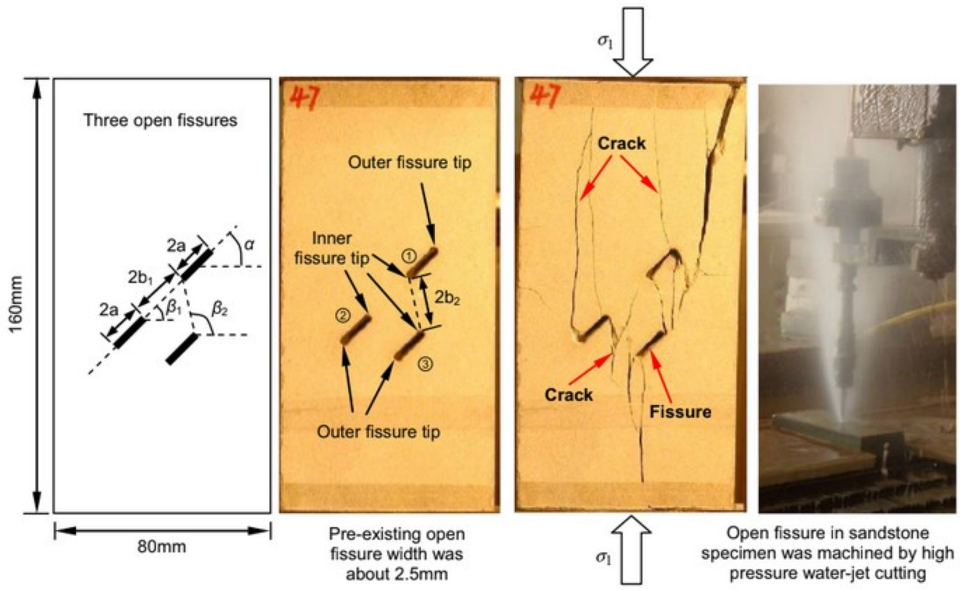


Figure 21. Creating non-persistent open fissures in the sample by using water jet [21].

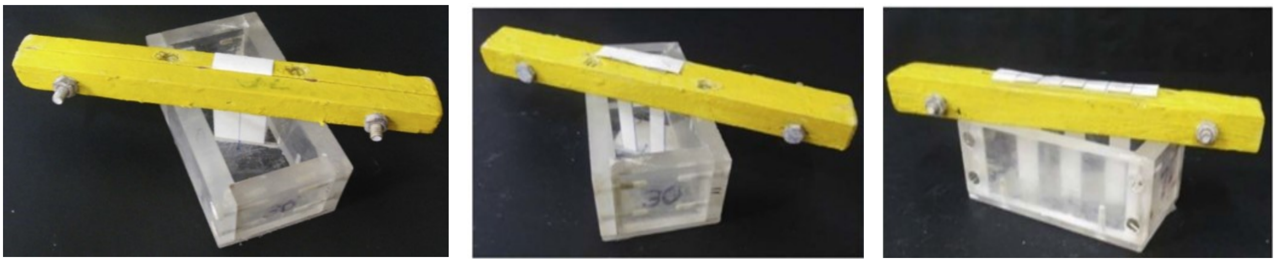


Figure 22. Making method of a sample containing non-continuous joints [22].

To date, the method of making heterogeneous samples containing non-persistent joints has not been studied [23-26]. The purpose of this study is to create non-persistent joints in heterogeneous samples with different methods. Different materials were tested, and the best material for preparing the heterogeneous samples was proposed. Deficiency of concrete material was described. Also the deficiency of different methods for sample preparation was described.

2. Materials and Methods

For years, the researchers have been searching for suitable materials to simulate the behavior of rock mass (Figure 23) [27]. The materials chosen for this purpose should have the capability to model the physical and mechanical behavior, texture, and construction of rock samples as well as the potential to make changes in them such as creating joint surfaces in different forms.

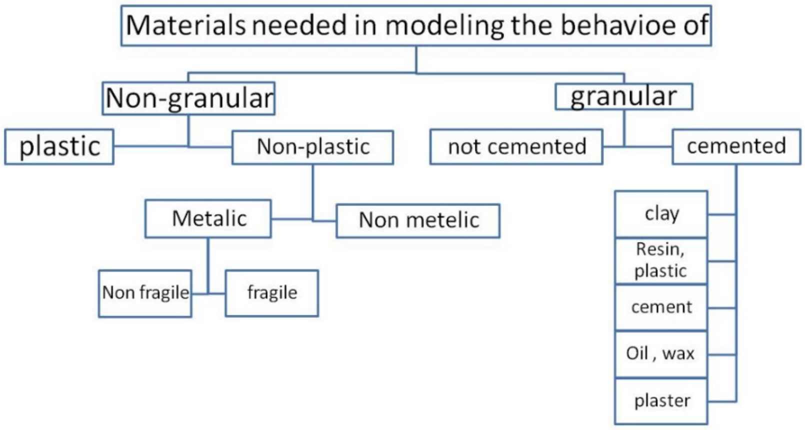


Figure 23. Simple classification of suitable materials for rock modeling [23].

Based on the past research work, one of the best compounds used to model the behavior of jointed rock is the plaster and cement materials, which have advantages such as cheapness, availability, and textural similarity with many types of rocks.

2.1. Choosing desired item

Since at least two rock like materials with different mechanical properties are required to make heterogeneous samples containing non-persistent notch (Figure 24), plaster and concrete were chosen for this purpose. However, the connection of plaster to concrete faces has some limitations including different modulus of elasticity of the plaster and concrete, which causes them not to be connected properly. Also concrete needs to be immersed in water to reach its final strength, in which case plaster is immersed along with concrete. Therefore, the option of concrete was removed and reinforced plaster was chosen as the second rock like material.

To make ordinary plaster samples, the ratio of chalk to water was chosen equal to 1/2 (Figure 25). Also for making reinforced plaster, the ratio of chalk to water was chosen as 1/2. Also 30 g of polyvinyl acetate (PVA) was used in one kilogram of plaster (Figure 25).

Polyvinyl acetate, commonly referred to as wood glue, white glue, carpenters glue, or PVA glue, is an aliphatic rubbery synthetic polymer with the formula ($C_4H_6O_2$). It was also used here in our present work as an additive to plaster works. Vinyl acetate is produced from ethylene by reaction with oxygen and acetic acid over a palladium catalyst. Under the action of free radical initiators, vinyl acetate monomers (single unit molecules) can be linked into long, branched polymers (large, multiple unit molecules). The monomer can be polymerized while dispersed in water to form a milky-white emulsion. This fluid can be processed directly into latex paints, in which PVA forms a strong, flexible, adherent film. It can also be made into a common household adhesive known as white glue or Elmer's glue.

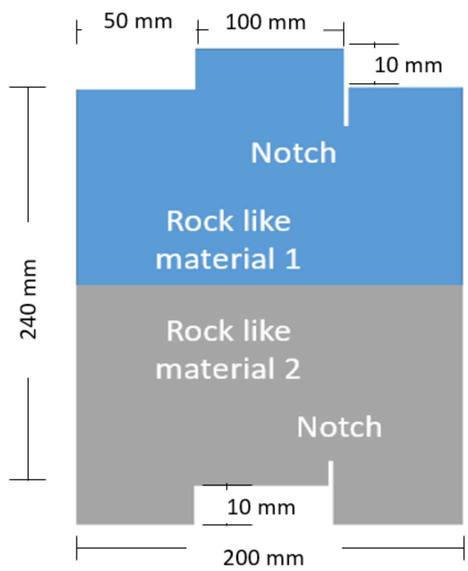


Figure 24. Schematic view of heterogeneous samples containing non-persistent notches.

First, chalk was dissolved in water. Then polymer material was added and plaster slurry was poured into the mold. Cylindrical samples had a diameter of 54 mm and a height of 118 mm. The disk samples had a diameter of 54 mm and a height of 27 mm. To determine uniaxial compressive strength and indirect tensile strength, the samples were subjected to the uniaxial compression test and Brazilian test (Figure 26). A type uniaxial compression machine with a measuring range of 300 KN (Figure 26) was used to test the mechanical properties of the specimens. The lab configuration contains a testbed, a system for gathering information, and the loading control system. The casted samples were put in the center of the bottom. The test adopted the displacement loading method for control. In the tests, the loading rate was set to 0.25 mm/min, and the stress−strain curve was monitored. A constant rate loading process was applied, and the loading rate was sufficiently slow to ensure that the sample was static. Loading was stopped immediately once the peak load was reached to ensure the specimen integrity for observing and describing the failure mode.

Figure 25. Cylindrical samples prepared from plaster and reinforced plaster for the uniaxial compression tests.

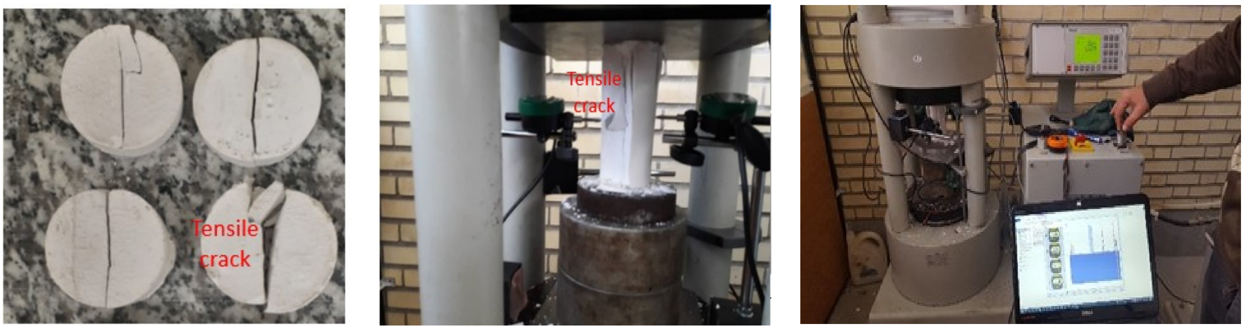


Figure 26. Conducting uniaxial compressive test and Brazilian tension.

Figures 27 (a) and (b) show the axial stress curve in terms of axial strain for normal plaster and reinforced plaster samples. The compressive strength of reinforced plaster is twice the compressive strength of normal plaster. Compressive strength of reinforced plaster was 2.3 times more than that of compressive strength of normal plaster. Table 1 shows the values of compressive strength and tensile strength of ordinary plaster and reinforced plaster.

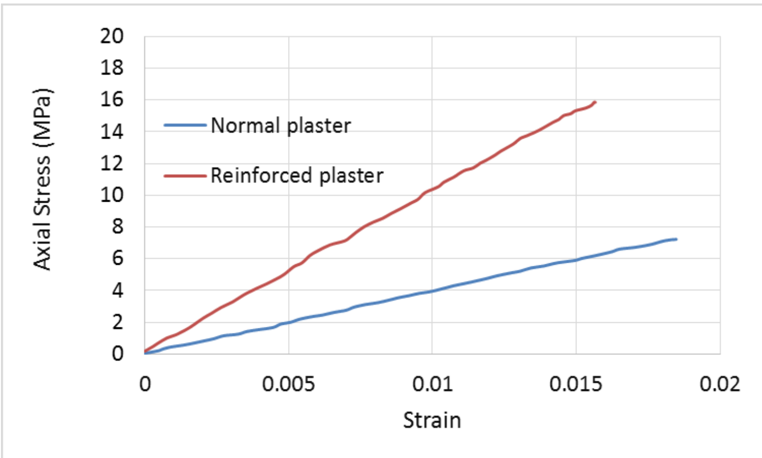


Figure 27. Axial stress curve in terms of axial strain for both the normal plaster and reinforced plaster.

Table 1. Results of compressive strength and tensile strength tests of ordinary plaster and reinforced plaster.

Mechanical properties (MPa)	Ordinary plaster	Reinforced plaster
Compressive strength	7.1	15.9
Tensile strength	0.8	1.2

3. Results and Discussion

3.1. Creating a notch using a sheet

Medium-density fiberboard (MDF) with dimensions of 200 mm x 240 mm x100 mm was used to make the main molds (Figure 28a). To create a plaster sample geometry similar to Figure 24, a timber with dimensions of 10 mm x100 mm x100 mm was embedded in the bottom of the mold (Figure 28b). Also two grooves were created on the bottom of the mold and on the top of the mold cover to make a notch (Figure 28c). In order to see inside the molds while filling them, a plexiglas was used in one dimension (Figure 28d). The oily plexiglas sheet is placed in the grooves. After lubricating the mold, the slurry enters into the mold through the upper chamber. To make a heterogeneous sample, firstly, ordinary plaster slurry was poured into the mold. After 15 minutes, the reinforced plaster slurry was poured into the mold. Based on the required geometry, which consisted of several layers, the slurries were poured into the mold step to step. After 15 minutes since pouring the last slurry layer, the mold was opened and the sample was removed from the mold. Notch was prepared concurrent with sample preparation. Figure 29 shows the sample that was made using this method. Due to the pressure of the plaster slurry on the sides of the plexiglas sheet, this plate was deviated from the vertical position and an unstable notch was created. Therefore, this method cannot be used to make the samples.

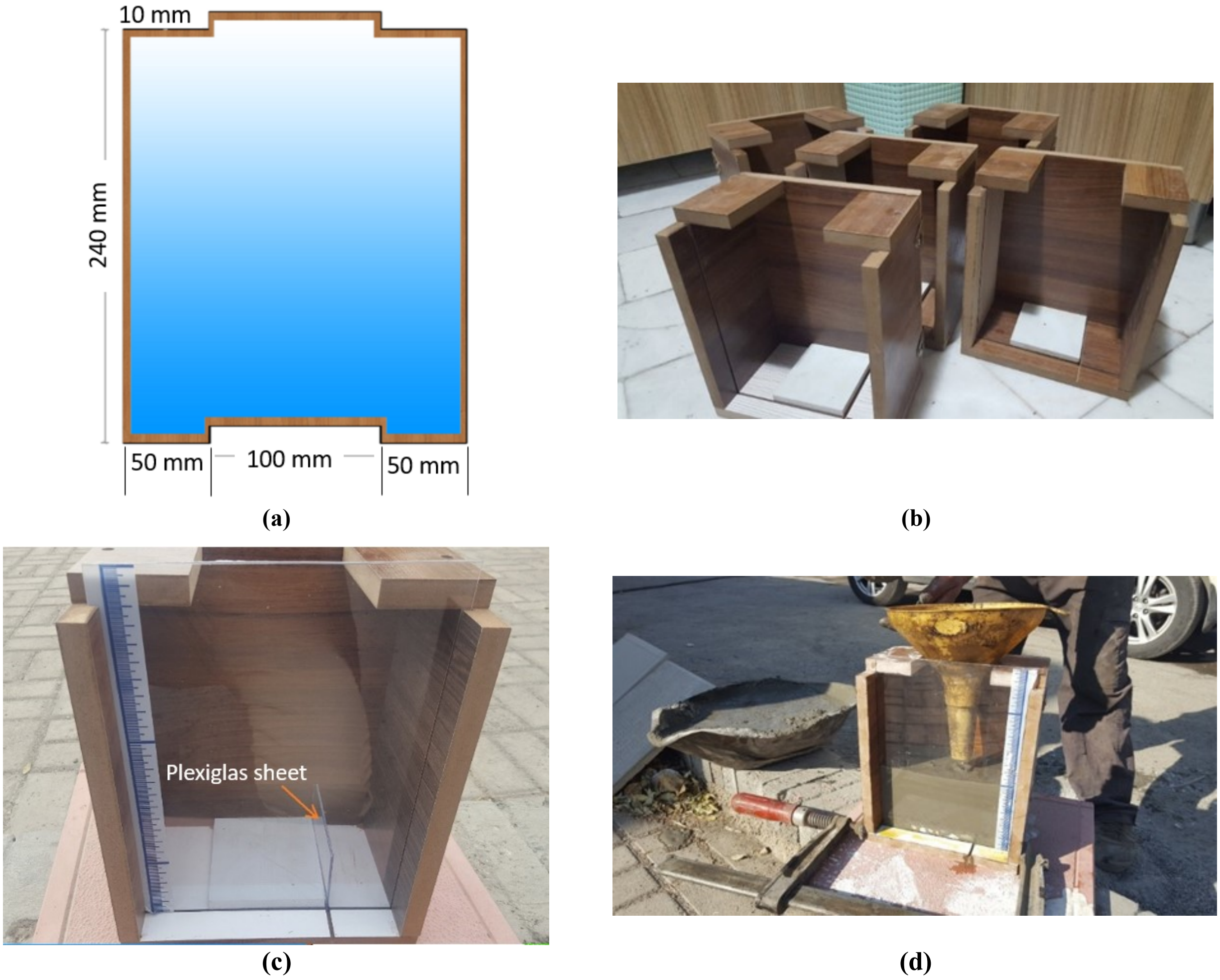


Figure 28. (a) Schematic views of the mold, (b) MDF mold, (c) groove on the bottom of the mold and plexiglas sheet inside the groove, and (d) pouring the slurry step by step into the mold.

Figure 29. Sample containing a non-standard notch.

3.2. Creating a notch using water jet

The second method used to create a notch on the samples was water jet method (Figure 30). In this way, the geometry of the sample was first made using the original mold. Then the notches were created using water jet. Five minutes it takes to prepare one notched sample. Since water has an effect on plaster and dissolves it, this method is also rejected for making notches on the plaster samples.

3.3. Creating a notch by using electric saw

In this method, the geometry of the sample was first made by using the original mold. Then the notches were created using an electric saw (Figure 31). Three minutes it takes to prepare one notched sample. Since the vibration caused by the movement of the saw causes changes in the body of the samples and also the vibration of the saw reduces the resistance of the crack tip material, the use of a saw is not recommended.

Figure 30. Using a water jet to create a joint.

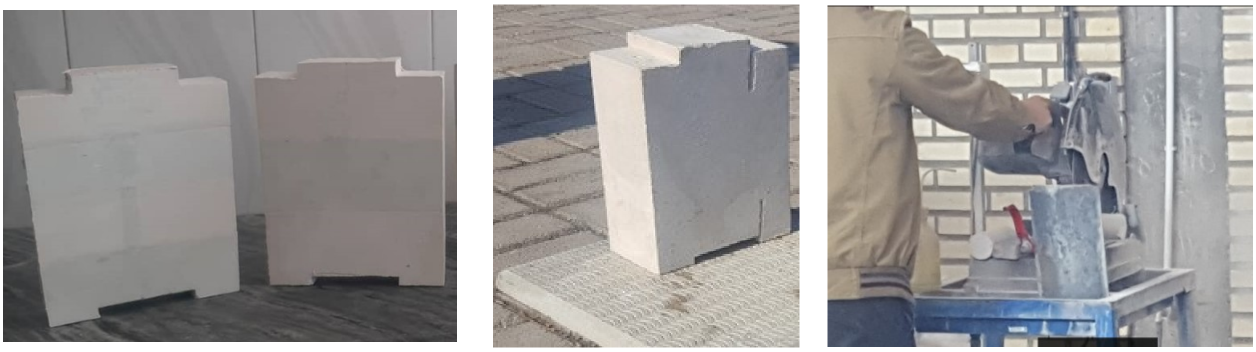


Figure 31. Using an electric saw in making a sample with non-persistent notches.

3.4. Creating a notch using saw thread

This method uses saw thread when the sample is not completely dry (Figure 32). In this method, the geometry of the sample was first made using the original mold. Then the notches were created using a saw thread. Ten minutes it takes to prepare one notched sample. Since due to the pressure caused by cutting, changes are made in the body of the samples and also the notch is not uniform, it is not recommended to use thread.

3.5. Creating a notch by using diamond wire cutter

Using diamond wire cutters, the fifth method creates a notch on the sample (Figure 33). In this method, the geometry of the sample was first made by using the original mold. Then the notches were created using diamond wire cutters. Five minutes it takes to prepare one notched sample. Since the vibration of the diamond cutting wire has an effect on the resistance of the joint tip material and causes a decrease in the material strength, it is not recommended to use diamond wire cutters.

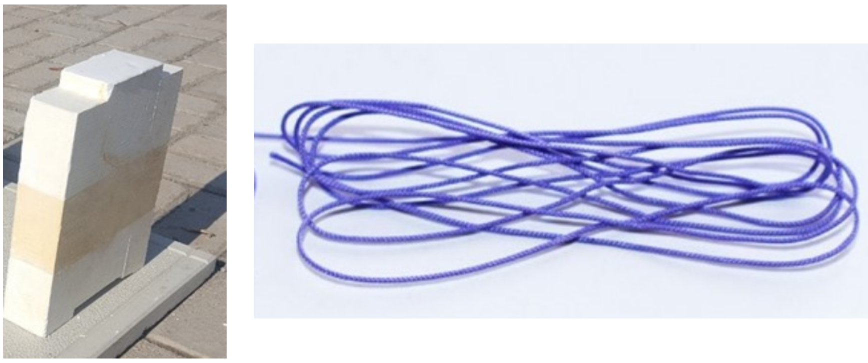


Figure 32. Use of saw thread in making of samples containing non-persistent notches.

Figure 33. Use of diamond wire cutters in making of samples containing non-persistent notches.

3.6. Creating a notch using hand saw

The sixth method creates a notch on the sample by using a hand saw with fine teeth after the sample is completely dry (Figure 34). In this way, the geometry of the sample was first made using the original mold. Then the notches were created using a hand saw. Via this method, none of the previous problems occurred. Therefore, a hand saw with fine teeth was used to create irregular notches in heterogeneous samples with different lengths (Figure 35). Fifteen minutes it takes to prepare one notched sample. It is to be noted that this device is not practical in high strength specimens.

Figure 34. Use of a hand saw in making a sample with non-persistent notches.

Figure 35. Samples of four layers with different notch lengths.

4. Conclusions

In this work, to study the behavior of heterogeneous rock like samples, different materials such as plaster and concrete were used in the form of different layers. The results show that the use of concrete as the second heterogeneous material was rejected since the connection of plaster to concrete faces some limitations including different modulus of elasticity of plaster and concrete, which causes them not to connect properly. Also concrete needs to be immersed in water to reach its final strength, in which case plaster is immersed along with concrete. Therefore, plaster reinforced with polymer materials was used as the second rock like material in heterogeneous samples. Also six methods for the preparation of heterogeneous samples containing notches were presented, and the best method was selected for making the samples. Using plexiglas sheet was rejected due to the pressure exerted by the slurry on it and the deviation of the sheet and the creation of non-uniform notches. Water jet was not suitable due to the effect of water on the plaster and dissolving the plaster. Employing electric saw and diamond cutting wire was rejected due to vibration and the creation of unwanted cracks. Thread in the semi-dry sample was not recommended because of the change in the cross-section of the sample and the creation of non-uniform notches. Finally, utilizing a hand saw was suggested. In a manual saw, the sample was sawed in a dry state and uniform notches were created.

Acknowledgements

This work was supported by the president research office of Bu-Ali Sina University, Iran (grant numbers 4.99, 2020), which is gratefully acknowledged. Also preparation of rock-like samples and conducting experiments was undertaken in the Engineering Geology and Geotechnical Laboratory of Bu-Ali Sina University. Therefore, thanks and appreciation of the contributions made in this field.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1]. Tsiambaos, G. and Saroglou, H. (2010). Excavatability assessment of rock masses using the Geological Strength Index (GSI). Bulletin Engineering Geoloy and the environment. 69:13–27.

[2]. Sarfarazi, V., Asgari, K., and Mohamadi Bolban Abad, Sh. (2022a). Interaction between one internal hole and two neighboring joints under uniaxial compression using an experimental test and a numerical simulation. Journal of Mining and Environment. 13 (2): 407-420.

[3]. Amini, M.S., Sarfarazi, V., and Babanouri, N. (2021). Influence of non-persistent joint sets on the failure behaviour of concrete under uniaxial compression test. Computers and Concrete. 28 (3): 289-309.

[4]. Fu, J., Sarfarazi, V., Haeri, H., Naderi, K., Fatehi Marji, M., and Guo, M. (2022a). The comparison between NBD test results and SCB test results using experimental test and numerical simulation. Advances in Concrete Construction. 13 (1): 83-99.

[5]. Bagher Shemirani, A., Haeri, H., Sarfarazi, V., Ebneabbasi, P., and Fatehi Marji, M. (2020). Investigation of the interaction between concrete-gypsum interface and internal notch using experimental test and numerical simulation. Mechanics Based Design of Structures and Machines, 1-24.

[6]. Fu, J., Haeri H., Sarfarazi V., Noshadi, A.H., Fatehi Marji, M., and Guo, M. (2022b). Investigating the failure behavior of gypsum specimens with non-persistent vertical notch under uniaxial compression. Strength of Materials. 54 (1): 14-32.

[7]. Shakeri J., Asadizadeh, M., and Babanouri, N. (2022). The prediction of dynamic energy behavior of a Brazilian disk containing nonpersistent joints subjected to drop hammer test utilizing heuristic approaches. Neural Computing and Applications. 34: 9777–9792.

[8]. Sarfarazi, V., Asgari, K., Maroof, S., and Fattahi, Sh. (2022). Effects of number and angle of T Shape non persistent cracks on the failure behavior of samples under UCS test. Computers and Concrete. 29 (1): 31-45.

[9]. Fu., J., Haeri H., Sarfarazi V., Asgari, K., and Fatehi Marji, M. (2022) The shear behavior of concrete-gypsum specimens containing double edge cracks under four-point loading conditions. Theoretical and Applied Fracture Mechanics. 119: 103361.

[10]. Fu., J., Sarfarazi V., Haeri H., Shahbazian, A., Fatehi Marji, M., Yu, Y. (2022) Study of tensile crack growth in rock-like materials under punch shear test. Theoretical and Applied Fracture Mechanics. 121: 103509.

[11]. Sarfarazi, V., Asgari, K., Zarei, M., and Ghalam, E.Z. (2022c). Behavior of F shape non-persistent joint under experimental and numerical uniaxial compression test. Advances in Concrete Construction. 13 (2): 199-213.

[12]. Yang, W., Li, G., Ranjith, P., and Fang, L. (2019). An experimental study of mechanical behavior of brittle rock-like specimens with multi-non-persistent joints under uniaxial compression and damage analysis. International Journal of Damage Mechanics. 28 (10): 1490-1522 .

[13]. Haeri, H., Sarfarazi ,V., and Naderi, A.A. (2021). Shear mechanism of non-persistent notches using punch shear test. Iranian Journal of Science and Technology, Transactions of Civil Engineering. 46 (1): 237-250.

[14]. Haeri, H., Sarfarazi ,V., Ebneabbasi, P., Nazari maram, A., Shahbazian, A., Marji, M.F., and Mohamadi, A.R. (2020). XFEM and experimental simulation of failure mechanism of non-persistent joints in mortar under compression. Construction and Building Materials. 236: 117500 .

[15]. Asadizadeh, M., Karimi, J., Hossaini, M.F., Alipour, A., Nowak, S., and Sherizadeh, T. (2022). The effect of central flaw on the unconfined strength of rock-like specimens: an intelligent approach. Iranian Journal of Science and Technology. Transactions of Civil Engineering. 46: 3679–3694.

[16]. Sarfarazi, V., Hajiloo, M., Zarrin Ghalam, E., and Ebneabbasi, P. (2020). Study of tensile behavior of Y shape non-persistent joint using experimental test and numerical simulation. Computers and Concrete. 26 (6): 565-576.

[17]. Zhou, L., Sarfarazi, V., Haeri, H., Ebneabbasi, P., Fatehi Marji, M., and Hassannezhad Vayani, M. (2021). A new approach for measurement of the fracture toughness using the edge cracked semi-cylinder disk (ECSD) concrete specimens. Mechanics Based Design of Structures and Machines. 1-22.

[18]. Asadizadeh, M., Hossaini, M. F., Moosavi, M., Masoumi, H., and Ranjith, P. (2019). Mechanical characterisation of jointed rock-like material with non-persistent rough joints subjected to uniaxial compression. Engineering Geology. 260: 105224.

[19]. Fu, J., Haeri, H., Sarfarazi, V., and Fatehi Marji, M. (2022e). Interaction between the notch and mortar-mortar interface (with different inclinations) in semi-circular bend specimens. Iranian Journal of Science and Technology, Transactions of Civil Engineering. 46: 2747–2763.

[20]. Sarfarazi V., Abharian S., and Ghorbani, A. (2021). Physical test and PFC modelling of rock pillar failur containing two neighboring joints and one hole. Smart Structures and Systems. 27 (1): 123-137.

[21]. Yang Sh., Huang Y-H., Ranjith, P. G., Jiao, Y-Y, and Ji, J. (2015). Discrete element modeling on the crack evolution behavior of brittle sandstone containing

three fissures under uniaxial compression. Acta Mechanica Sinica. 31: 871–889.

[22]. Shaunik, D., & Singh, M. (2019). Strength behaviour of a model rock intersected by non-persistent joint. Journal of Rock Mechanics and Geotechnical Engineering. 11 (6): 1243-1255.

[23]. Yaylaci M,Birinci A (2013). The receding contact problem of two elastic layers supported by two elastic quarter planes. Structural Engineering and Mechanics. 48 (2): 241-255.

[24]. Yaylaci M, Öner E, and Birinci A (2014). Comparison between Analytical and ANSYS Calculations for a Receding Contact Problem. Journal of Engineering Mechanics-ASCE. 140 (9): 4014070.

[25]. Yaylacı M and Avcar M (2020). Finite element modeling of contact between an elastic layer and two elastic quarter planes. Computers and Concrete, Vol. 26, No. 2 (2020), 107-114.

[26]. Yaylacı M, Terzi C, and Avcar M (2019). Numerical analysis of the receding contact problem of two bonded layers resting on an elastic half plane. Structural Engineering and Mechanics. 72 (6).

[27]. Stimpson, B. (1970). Modelling materials for engineering rock mechanics. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts. 7 (1): 77-121.

نحوه ساخت نمونه ناهمگن حاوی درزه‌های ناممتد با تمرکز بر روش‌های پیشنهادی مختلف

رحیم مرتضایی[۱]، سید داود محمدی[۱*] و وهاب سرفرازی[۲]

۱- گروه زمین شناسی، دانشگاه بوعلی سینا همدان، همدان، ایران

۲- گروه مهندسی معدن، دانشگاه صنعتی همدان، همدان، ایران

ارسال ۲۰۲۲/۱۰/۰۵، پذیرش ۲۰۲۲/۱۰/۲۸

* نویسنده مسئول مکاتبات: d.mohammadi@basu.ac.ir

چکیده:

یکی از مهمترین کارها در انجام تحقیقات ازمایشگاهی نحوه ساخت نمونه‌ها می‌باشد. هدف این تحقیق ایجاد نمونه‌های شبه سنگی ناهمگن حاوی درزه ناممتد است. برای ساخت نمونه‌های با هندسه شرایط برش پانچ، قالب‌هایی با ابعاد ۲۵۰ mm× ۲۰۰ mm× ۵۰mm ساخته شد. برای ساخت نمونه‌های ناهمگن، از مخلوط گچ و آب با درصد اختلاط متفاوت استفاده شد. برای ایجاد درزه‌های ناممتد از تکنیک‌های مختلفی استفاده گردید. یکی از روشها برای ایجاد درزه، قراردادن ورق آلومنیومی در درون شیار قالب و نهایتا خارج نمودن آن بعد از سخت شدن دوغاب بود که به علت جابجایی ورق و کج شدن آن در حین دوغاب ریزی، درزه‌ها از حالت عمود خارج می‌شدند. علاوه بر روش مذکور، روشهای دیگری مانند جت آب، برش با نخ، برش با سیم برش، برش با اره دوار و استفاده از اره دستی امتحان شد. که درنهایت استفاده از اره دستی برای ایجاد درزه در نمونه‌ها بعنوان بهترین روش انتخاب شد. نمونه‌ها تحت آزمایشات تک محوری قرار گرفتند و آزمایش برش پانچ انجام شد. نتایج نشان می‌دهند که استفاده از اره دستی نتایج قابل قبولی را در شرایط برش پانچ ارائه می‌دهد.

کلمات کلیدی: پلاستر، قالب‌های نمونه گیری، نمونه‌های ناهمگن، مدل آزمایشگاهی.