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Load deformation behavior of used tires foundation with varied Filler Gradation

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Abstract. In this study, waste tire is used as foundation material. Load deformation behavior was examined with varied aggregate filler gradation.Thetypes of gradation used are: (a) 1”<(15%)<1,5”,¾”<(25%)<1”,¾<(60%)<no.4;(b)¾”<(50%)<1”,no.4<(50%)<3/4”; (c) ¾”<(100%)<1”, and (d) natural gravel 1”<(34,66%)<1,5”, ¾”<(65,34%)<1”, gradation as found in BiliBili river. Tires waste used in this study was R.16 which had been modified.Before conducting field tests, abrasion and specific gravity values of each aggregate were obtained. With applying load of20 kN, the vertical center deformationof gradation(a) was 6 mm, gradation(b) was 6mm, gradation(c) was 9 mm, and gradation (d) was 3 mm. While horizontal side deformationgradation(a) was 19,3 mm, gradation(b) was 48 mm, gradation(c) was18,8 mm, and gradation (d) was 19,2 mm.

1. Introduction

Tire waste is one of the biggest waste contributors and it is a material that cannot be decomposed by the environment also very invulnerable to chemical and acid. Destructing used tires by burning is also quite difficult, because used tires will only burn at temperatures above 322 ° Cand produce compounds that are very dangerous for health and the environment. Although the material is difficult to destroy, used tire waste has several physical properties that can be utilized. One of the positive characteristics of rubber waste is that it is resistant to water, has good flexibility and flexural properties and able to absorb vibrations. Tires have elastic properties that have a strong mechanical capacity and are easily available at low prices.An object will deform if given a force, i.e. changes in size or shape. If the force is removed, then the object back to its original shape, it is said to be elastic.

The amount of length increase or shape changes experienced by each object when stretched, differ from one object to another depending on the elasticity of the material. A measure of the ability of a material to resist changes in shape or bending that occur up to the limit of proportions is called Modulus of elasticity (E). Modulus of elasticity is often called Modulus Young which is the ratio between stress and axial strain in elastic deformation. Stress is the force distribution per unit area, while the strain is the change in length per unit of original material length. The higher the modulus of elasticity of the material, the less change in shape that occurs when applied to the force. So that the greater modulus elasticity, the smaller elastic strain that occurs or rigid. Modulus of elasticity is related to strain, deflection and shape changes that occur. The amount of deflection is influenced by the size and point of loading, the length and size of the cross section and the modulus of elasticity of the material.[3]. The nature and shape of aggregate gradations determine the ability of used tires to carry the load above them. Good quality and quality aggregates are needed for used tire fillers.

2. Theoretical principle

2.1. Aggregate shape
Aggregate grains in various sizes are expressed as aggregate gradations. The shape of the aggregate influences the strength of a foundation.

2.1.1. Aggregate particle shapes
- Rounded
  Aggregates found in rivers have generally been eroded by water so that they are generally spherical in shape. Smaller contact area produces lower interlocking power which easier to slip.
- Elongated
  Long-shaped aggregate particles can be found in rivers or former river deposits. Aggregates are said to be oval if the longest size is > 1.8 times the average diameter. Its interlocking properties are almost the same as those with a round shape.
- Cubical
  Cube-shaped particles are an aggregate form from a stone crusher which have wider contact area so as to provide greater interlocking properties. Thus, it is more resistant to deformations that occur.
- Flat
  Flat-shaped aggregate particles are also result of stone crusher machines or indeed are the nature of these aggregates which, if broken, tend to be flat. Flat aggregates are aggregates thinner than 0.6 times the average diameter. Flat-shaped aggregates break easily during mixing, compaction, or due to traffic loads.
- Irregular
  Irregular aggregate particles do not follow the one mentioned above.Surface texture affects the bond between the stone and asphalt. Aggregate surface texture usually consists of very rough, rough, Smooth and polished.

Figure 1. Typical aggregate shape.

2.1.2. Aggregate classification
Aggregate classification can be distinguished based on the group of occurrence, processing, and grain size. The aggregate classification, ie:
- *Based on Occurrence*
  - Igneous Rock
    Aggregates derived from magma that cools and freezes. Distinguished over rocks outer igneous (extrusive igneous rock) and igneous internal rocks (intrusive igneous rocks). Formed from magma that comes out to the surface of the earth when avolcanoerupts.

- Sediment Aggregate
  Derived from a mixture of mineral particles and freezing and decomposed animal or plant. In general, the layers on earth's crust, the result of sedimentation in lakes, oceans and so on.
- Metamorphic Aggregate
  Derived from sedimentary rocks or igneous rocks undergoing a process of change in shape and due to changes in pressure and temperature of the earth's crust. Based on the structure, it can be distinguished from metamorphic aggregates such as marble, quartzite, and metamorphic aggregate, layered like slate, flite, schist.

- *Based on Processing*
  - Natural Aggregate
    Aggregates that can be used as they are in nature or with little processing. Thisaggregate is formed through a process of erosion and degradation. Particle shape of natural aggregate determined its formation process.
  - Aggregate Through Processing
    In mountains, hills, and rivers are often found material that are still in boulder form so that it needs to be processed before it would be able to be used as construction material.
  - Synthetic Aggregate
    Aggregate which is a filler (particle size < 0,075 mm), obtained from by-products of cement factories or stone crushing machines. This synthesis / artificial aggregate as a result of modification, both physically or chemically. Such aggregates are added to the refining process of iron ore or special produced or processed from raw materials used as aggregates. Slags are the most commonly used as artificial aggregates. Slag that floats on molten iron is not a metal, then its size is reduced and air cooled. The use of synthetic aggregates for coating bridge floors,because synthetic aggregates are more durable and more resistant to shearing than natural aggregates.

2.2. Aggregate gradation

- Continues Gradation
  Continues Gradation is a condition where gap between similar sized aggregates filled with smaller aggregates, the smaller gap between same smaller aggregate filled with even smaller aggregate and so on. Also named as dense graded due to its density by interlocking.
- Gap Graded
  Gap graded is a condition where in a gradation, gap occurred due to absence of mid-sized aggregate. Material differences qualify for sequential intermediate grain sizes, if above 10% named continues gradation, if below 10% named gap graded. There is a specification that states that percent passes to weight for No.30 minimum should be 80% from No.8. FromNo 8 until No 30 occupied by No. 16 in between, so the application of the provisions mentioned above is still relevant because from No.8 to No.16 is 10% and from No 10 to No. 30 is 10%, if added up then it is equal to 20%.
- Uniform Graded
  Uniform gradation is aggregate grains which are of the majority one size, usually there are still a few fine grains that carry along. These gradations are not prone to segregation and are generally crusher products whose proportions are easily adjusted to achieve the desired gradation.

2.3. Deformation

Deformation occurs when a material experiences a force. During deformation, materials absorb energy as a result of the forces acting along the deformation. No matter how small the force works, the object will change shape and size. This change in physical size is called deformation. There are two kinds of deformations, namely elastic deformation and plastic deformation. What is meant by elastic deformation is deformation that occurs due to a load that if the load is removed, the material will return to its initial size. While plastic deformation is deformation that is permanent if the load is released, (Edi Jasmani, 2001). Increasing load to the material which has experienced its highest strength cannot be done, because in this condition the material has undergone total deformation. If the load is still given then the strain will increase where the material seemed to strengthen which is called the strain strengthening (strain hardening) which then the object will break. (Singer danPytel, 1995).

- Strain
  Deformation that occurs in a rod element that receives an external load depends on the initial size of the cross section, so that it is more precise if expressed in the form of strain which is the comparative value of changing the dimensions of the unity of size to its initial dimension, strain can also be defined as a non-dimensional expression of deformation.
- Normal Strain
  Based on the length dimension of the stem element (Lo) which receives a tensile load of P, an extension of ΔL will occur in the rod element. The normal stretch size can be expressed in the form of the following equation:

$$\varepsilon = \frac{\Delta L}{L_o} \quad (1)$$

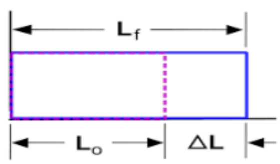

Figure 2. Normal Strain in Block Element.

2.4. Loading

Structure is a collection of material elements that can carry loads or loading forces on other elements that are finally safely conveyed to the ground. The loading system in a construction can be divided into:

- Direct Load, is a load or load that is forwarded directly to soil or other structural elements.
- Indirect Load, is a load that passed on directly to the ground or other structural elements.

According to the Indonesian Loading Regulations for Buildings (PPIUG), loads are divided into 5 types:

- Dead Load (M), is load that is fixed or constant. Example: structure load such as roofs, roof trusses, beams, floors, etc.
- Live Load (H), is a load that is not fixed, moving, changing anytime. Example: humans, various furniture, etc.
- Wind Load (A), is load in the form of wind in all directions and its speed.
- Earthquake Load (G), is load in the form of earthquake or movement (shift) the earth's soil layer.
- Special Load (K), are loads which are simplifications everyday reality. Examples: settlement, weather effects, heat, temperature, shrinkage, etc.

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3. Methodology

3.1. Research flowchart

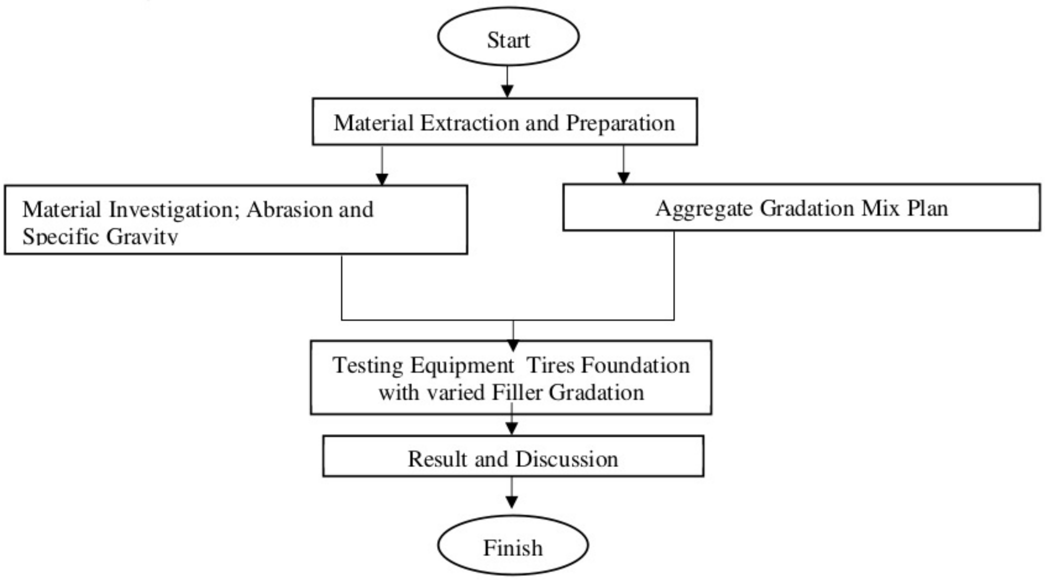


Figure 3. Research's flow chart.

3.2. Material extraction and preparation

All materials used are locally gathered. Coarse aggregate extracted directly at quarryin Gowa regency. Tires bought at stores in Jalan Bandang Makassar. Natural gravel as found in Bili-Bili river.

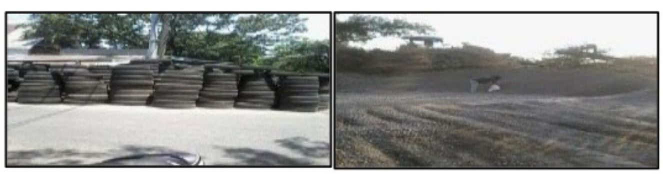


Figure 4. Material location visual.

Tests conducted in the laboratory are based on testing standard. Here are standards used in this research.

Table1. Testing Standard.

No.	Test	Standard
1	Abrasion	SNI 03- 2417-2008
2	Specific Gravity	SNI 03-1964-1990

3.3. Gradation mix

- Aggregate Gradation
  Gradation 1"<(15%)<1,5", ¾"<(25%)<1", no.4<(60%)<3/4"
  Gradation ¾"<(50%)<1", no.4<(50%)<3/8"
  Gradation ¾"<(100%)<1"
  Gradation natural gravel 1"<(34,66%)<1,5", ¾"<(65,34%)<1"
- Modified R16 Tire

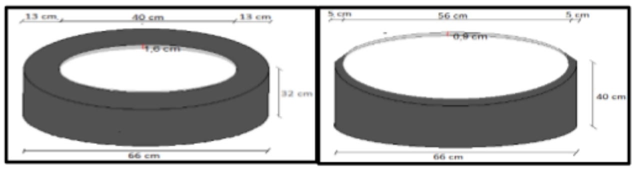


Figure 5. Common R16 tire (left) and modified R16 tire (right).

3.4. Testing equipment tires foundation with varied filler gradation

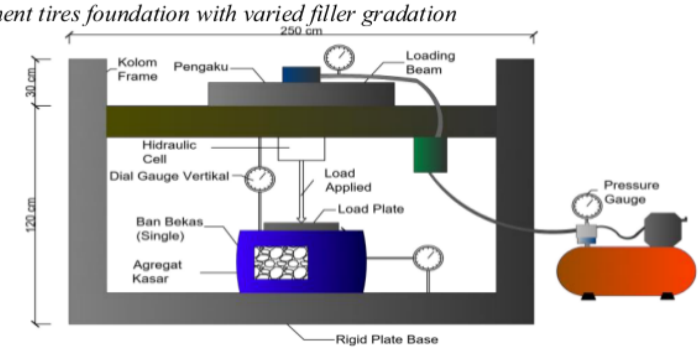


Figure 6. Testing scheme.

Testing Procedure**:**

- Preparation of modified R16 tire
- Aggregate Preparation:
  - Gradation 1"<(15%)<1,5", ¾"<(25%)<1", no.4<(60%)<3/4"
  - Gradation ¾"<(50%)<1", no.4<(50%)<3/8"
  - Gradation ¾"<(100%)<1"
  - Gradtion natural gravel 1"<(34,66%)<1,5", ¾"<(65,34%)<1"
- Load frame preparation
- Put the modified tire below loading frame along with aggregate inside
- Set up dial and load cell (hydraulic)
- Start loading and measure the deformation

4. Result and discussion

Before conducting the test in loading frame, first the physical abrasion and specific gravity of the aggregate are tested

4.1. Abrasion and specific gravity result

Table 2. Aggregate Properties Test Results.

No	Test	Term	Aggregate 1.5”	1”	3/4”	3/8”	Natural Gravel
1	Abrasion	<40	9.32	17.52	23.52	25.12	9.32
2	Specific Gravity	>2,5	2.63	2.63	2.65	2.65	2.63

4.2. Used tire gradation filler test

With applying load of 20 kN, spacious base for loads with d= 20 cm

$$A = \pi r^2 \tag{2}$$
$$= 3{,}14 \ 10^2 = 314 \text{ cm}^2$$

Vertical Deformation in center position on tire foundation and horizontal deformation in making side tire foundation .Coefficien of uniformity (Cu) and Coefficien of gradation (Cc):

$$Cu = \frac{D60}{D10} \tag{3}$$

$$Cc = \frac{(D30)^2}{(D10)} \tag{4}$$

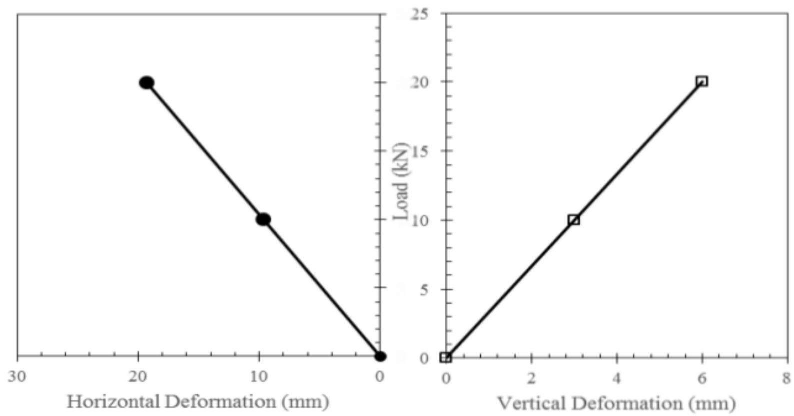
The four variations of used tire fillings aggregate are shown in table below.

Table 3. Loading test result.

Gradation	CC	CU	Horizontal Deformation (mm)	Vertical Deformation (mm)	Voltage q=P/A kN/cm²	Load P(kN)
1”<(15%)<1,5”, ¾”<(25%)<1”, no.4<(60%)<3/4”	1.04	2.67	9.65	3	0.0318	10
¾”<(50%)<1”, no.4<(50%)<3/8”	1.07	2.88	24	3	0.0318	10
¾”<(100%)<1	0.58	1.44	9.4	0.45	0.0318	10
Natural Gravel 1”<(34,66%)<1,5”, ¾”<(65,34%)<1”	1.03	2.57	9.6	1.5	0.0318	10
1”<(15%)<1,5”, ¾”<(25%)<1”, no.4<(60%)<3/4”	1.04	2.67	19.3	6	0.0636	20
¾”<(50%)<1”, no.4<(50%)<3/8”	1.07	2.88	48	6	0.0636	20
¾”<(100%)<1”	0.58	1.44	18.8	0.9	0.0636	20
Natural Gravel 1”<(34,66%)<1,5”, ¾”<(65,34%)<1”	1.03	2.57	19.2	3	0.0636	20

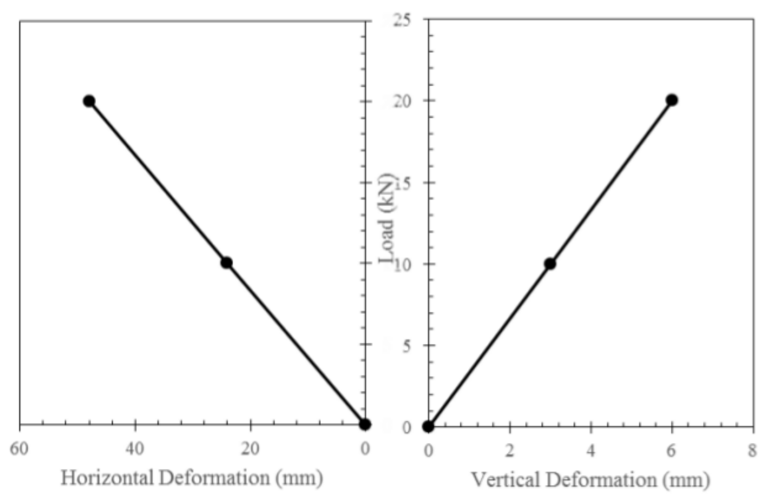
4.2.1. Deformation behavior

Load Deformation Behavior, Vertical deformation and Horizontal deformation described in figure below.



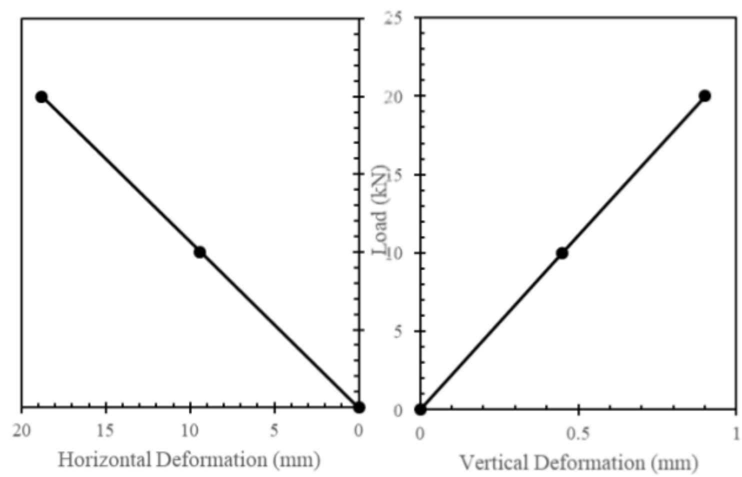
(Making side tire foundation, 20 cm from the base) (Center position on tire foundation)

Figure 7. Vertical-Horizontal Deformation of Gradation1”<(15%)<1,5”, ¾”<(25%)<1”, no.4<(60%)<3/4”.



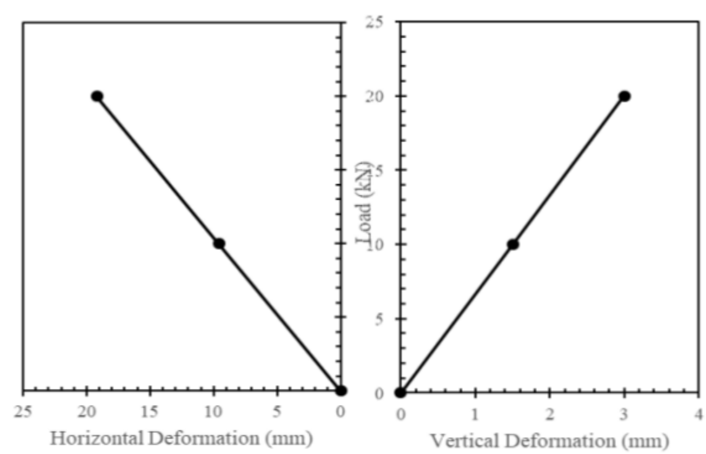
(Making side tire foundation, 20 cm from the base) (Center position on tire foundation)

Figure 8. Vertical-Horizontal Deformation of Gradation¾”<(50%)<1”, no.4<(50%)<3/8”.



(Making side tire foundation, 20 cm from the base) (Center position on tire foundation)

Figure 9. Vertical-Horizontal Deformation of Gradation ¾”<(100%)<1”.



(Making side tire foundation, 20 cm from the base) (Center position on tire foundation)

Figure 10. Vertical-Horizontal Deformation of Natural Gravel.

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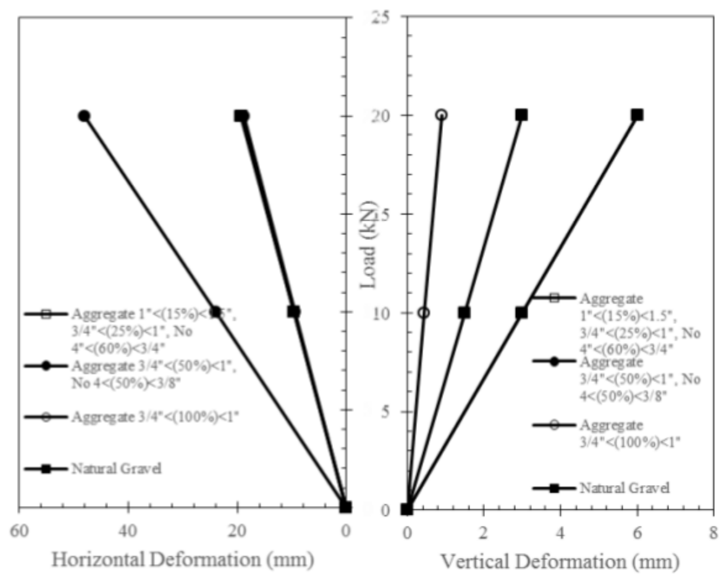

(Making side tire foundation, 20 cm from the base) (Center position on tire foundation)

Figure 11. Vertical-Horizontal Deformation of Grain Variations.

5. Conclusion

Based on the results of testing and discussion conducted can be concluded as follows:

- The results of horizontal deformation and vertical deformation tests have a linear pattern due to the load
- The smallest vertical deformation value of the four gradations is 0.9 mm gradation ¾ "<(100%) <1", Cu was 1.44 , Cc was 0.58
- The smallest horizontal deformation value of the four gradations is 19.2 mm natural gravel gradation 1"<(34,66%)<1,5", ¾"<(65,34%)<1", Cu was 2.57, Cc was 1.03 and The largest is 48 mm ¾ "<(50%) <1", no.4 <(50%) <3/8 " **, Cu was 2.88, Cc was 1.07**

6. Acknowledgement

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