SOIL FOUNDATION IMPROVEMENT WITH TIRE-USED TO REDUCE SETTLEMENT OF SHALLOW FOUNDATION EMBEDDED ON SATURATED DEPOK CLAY

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ABSTRACT

One of soil foundation improvement methods to anticipate the problem of settlement is to use tire-used (pneusol). This is a preliminary study and aims to determine the reduction of vertical displacement or settlement on saturated clay reinforced with tire-used. Tire-used material generally has a density of between 8 and 10 kn/m3 and is usually classified as a material lightweight tire. Laboratory model test used 4 (four) models, model with and without tire-used and some variations of foundation model size (rollag). Ratio of the diameter of tire-used and rollag size is 0.60. Results are compared with the data obtained by plaxis program. Analysis of the plaxis program assumed that plane strain triangle element type; 6 (six) nodes element; mohr – coulomb criteria; and soil foundation in undrained condition. Results of the experimental model at laboratory works show that the tire-used can reduce the settlement of soil foundation up to 20% at maximum normal stress. However, the value of settlement obtained by experimental model at laboratory works could not be compared with the plaxis program results.

Keywords : tire used, hallow foundation, bearing capacity,settlement

INTRODUCTION

Several construction projects on soft soil land are always started previously by using ground improvement methods, such as: micro pile, preloading, dewatering, geotextile, etc (Holtz & Kovack, 1981). Soft soil has a small bearing capacity soft soil has a small bearing capacity and is unable to carry the working load on the structure (Terzaghi, 1943). However, ground improvement efforts are costly and implementation only for on large scale projects, such as: building hotels, offices, shopping malls/plazas, and others. For a smaller scale projects, such as: simple houses, the ground improvement become a less efficient since cost of some soil improvement methods can be higher than the cost of construction. From those reasons above, then it found a way to use tire-used (pneusol) as a support material for saturated soft clay soil (Long, 1984). Some advantages can be reached from the use of tire-used, these are:

a. Tire-used is a tough material decomposed by soil; it can be applied for a long time.
b. Tire-used is made of rubber and has a high elasticity.
c. Tire-used easily available and inexpensive in purchase price.

RESEARCH METHOD

Depok soft clay simple is taken from Soil Mechanics Laboratory of State Polytechnic area (Fig. 1). Fig. 1 shows that generally soil type at the study area is alluvial. The results of testing the physical properties of soil are shown in Table 1. Based on laboratory soil tests, soil type identified at study area is soft clay, and then we called as DepokClay.

Flow chart for all activities is shown in Fig. 2. The experiment uses four model tests and foundation model (rollag) in square shape, such as (as shown as Fig. 3): foundation model without tire-usedby rollagwhich has a size of 150 mm width (Model 1);foundation model used by the tire-diameter 200 mmand rollag width of 120 mm (Model 2);foundation model used by the tire-used diameter 250mmand rollag width of 150 mm (Model 3); and foundation model used by the tire-used diameter 300mmand rollagwidth 18 cm (Model 4). Configuration model of tire-used and rollag using the Newmark stress principle (1942) shows in Fig. 4. On each model, increment of loading and settlement occurred until soil collapse is observed and recorded. Results from all models are compared to identify some influences of tire-used addition and some effects of diameter variation of tire-used to reduce settlement.

Soil laboratory and foundation loading tests were performed at Soil Mechanics and Puri Fajar Mandiri, Co. From Figs. 2 and 3, soil was entered sequentially into a chamber layer by layer up to a thickness of 1000 mm, and each layer had a thickness of 100 mm and layer of soil was soaked with water to reach degree of saturation (Sr) = 100%. Foundation model or rollag was made by steel plate with a thickness of 150 mm. All tire-used were filled by sand to spread the vertical loading. Geotextile layer is used as a separator between the tire-used filled by sand and clay layer. In this case, friction factor between the geotextile and soil was considered not to contribute to shear strength of soil. Steel wire was used to bind tire-used in the model configuration and covered by plastic to avoid the corrosion. Then, loading and settlement data were observed and recorded in each model.

PLAXIS program is aimed to compare to results from experimental laboratory model tests. The running of PLAXIS program uses some assumptions, such as: the plane strain of triangle element type; 6 (six) nodes element; Mohr-Coulomb failure criteria; and undrained condition. Parameters of Depok clay; rollag; and tire-used are shown in Table 2.

RESEARCH RESULTS

Fig. 5 shows theresults of laboratory experiment of foundation loading test without and with tire-used. Fig. 5 (a) identifies foundation model without tire-usedbyrollagwhich has a size of 150 mm width (Model 1). At failure conditionon Model 1 (Fig. 5 (b)), total settlement occurred at vertical stress 373 kPa or failure condition on this model was generated by 53.9 mm. For foundation model used (Model 2; 3; and 3) by the tire-diameter 200 mm; 250 mm; and 300 mm bythesame of rollagsize at the failure condition of Model 1, total settlement was occurred 46.7 mm; 45.2 mm; and 42.5 mm, respectively.

From the Fig. 5, the test results show that the larger of tire-used diameter, the total settlement would be smaller. It can be concluded that the tire-used can be expanded the working stress area, and thus it can minimize the vertical stress occurred.

Fig. 6 shows all experimental results. From Fig. 6, it can be seen that tire-used can reduce the settlement up to 20%.

Fig. 7 shows the results of PLAXIS running program and identifies the pattern of behavior of the soil collapse on the model due to load testing. From Fig. 7, if the load is gradually applied to the foundation, settlement will increase. At a center point, when the load per unit area, a sudden failure in the soil supporting the foundation will take place and the failure surface in the soil will extend to the ground surface. Then, if the foundation under consideration rests on saturated clay soil of medium compaction without and with tire-used will also be accompanied by an increase in the settlement.

Fig. 7 (a) shows soil collapse model for rollag size of 150 mm2 without tire-used, soil supporting loaded by load per unit area will push the soil around rollag towards to the ground surface. However, the farther away from rollag loading, soil stress occurred will be smaller and it is represented by the larger of triangle element model.

From Fig. 7 (b), it can be seen that soil collapse model occurred under rollag with tire-used of 200 mm diameter steeper than without tire-used. It can be concluded that tire-used has a modulus of elasticity higher than the soil and contributes to add the soil strength around the foundation model or rollag. Fig. 7 (c) identifies that soil collapse model by using tire-used of 250 mm larger than the rollag with tire-used of 200 mm diameter. Fig. 7 (d) shows that the largest soil collapses model with tire-used of 300 mm diameter. From Fig. 7 (b); (c); and (d), it can be seen that the pattern of soil collapse model of foundation model system with the constant rollag size (150 mm2) without tire-used will be smaller than model foundation with tire-used generally.

Soil collapse condition that more extreme on foundation model with tire-used is caused by using fixed sized of rollag (150 mm2). The size of foundation model should be adjusted to foundation diameter models of tire-used. Model should consider a value of comparison between side size of the foundation model (s) and diameter of tire-used (d). The suitable value can impact concentration of soil stress around foundation model and push the soil towards to the ground surface.

CONCLUSION AND DISCUSSION

All experimental results from laboratory works shows tire-used can reduce the settlement up to 20%. However, the use of tire-soil can reduce the magnitude of settlement, comparison between the rollag size and the diameter of the tire-used (s/d) needto be considered. The experimental at laboratory required to provide some dial-gauge form onitoring settlement and soil heave condition around the rollag. Further research need to be developedforrecorded a significant data and soilcollapsecondition. Thus, the experimental results can compare exactly with the results of simulation Plaxis program.

Some results from Plaxis running program as a comparison to the laboratory experimental show that a value (s/d) can cause excessive heavec onditions that need to be considered when the soil around foundation model or rollag collapse. Then, the input parameters for the simulation program Plaxis must truly represent the actual circumstances.

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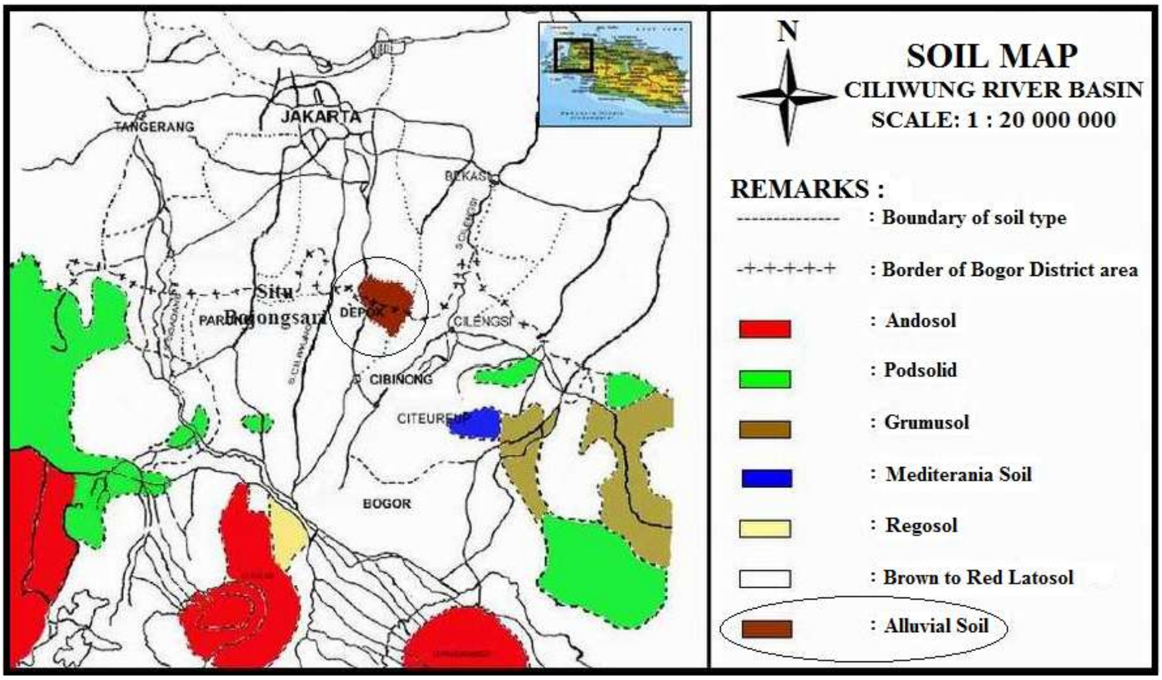


Fig. 1. Soil type based on soil map of Ciliwung River Basin(Pemerintah Kota Depok, 2010)

Tabel 1. Soil properties of Depok Clay

No.	Soil properties	Result
1.	Sieve analysis (> No. 200) (%)	98.6
2.	Hydrometer analysis diameter < 0.002 mm	86.5 (Clay)
3.	Specific gravity (G_s)	2.65
4.	Natural water content (w) (%)	80.7
5.	Atterberg limit:	
	Liquid limit (LL) (%)	76.0
	Plastic limit (PL) (%)	30.8
	Plasticity index (PI) (%)	45.2
6.	γ_{wet} (gr/cm^3)	1.90
7.	Void ratio (e)	2.4
7.	γ_{dry} (gr/cm^3)	1.21
8.	Optimum moisture content (w_{opt}) (%)	57.0
9.	Saturated ratio (S_r) (%)	95

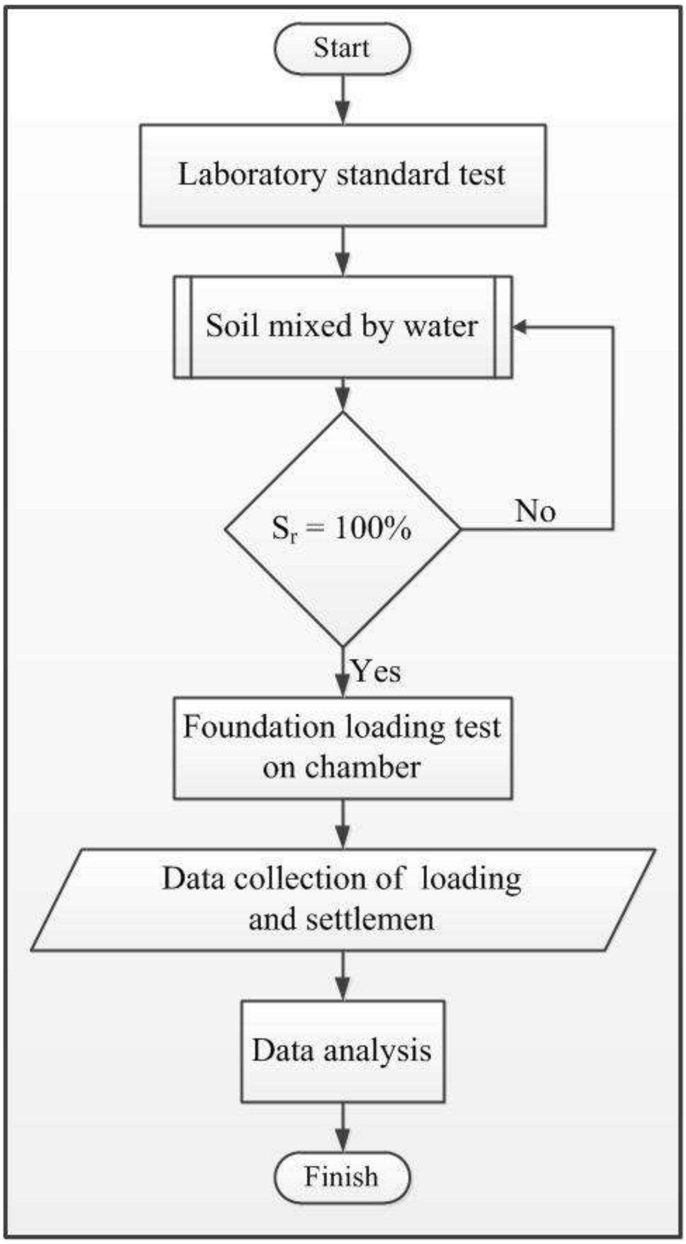


Fig. 2. Flow chart for research activities

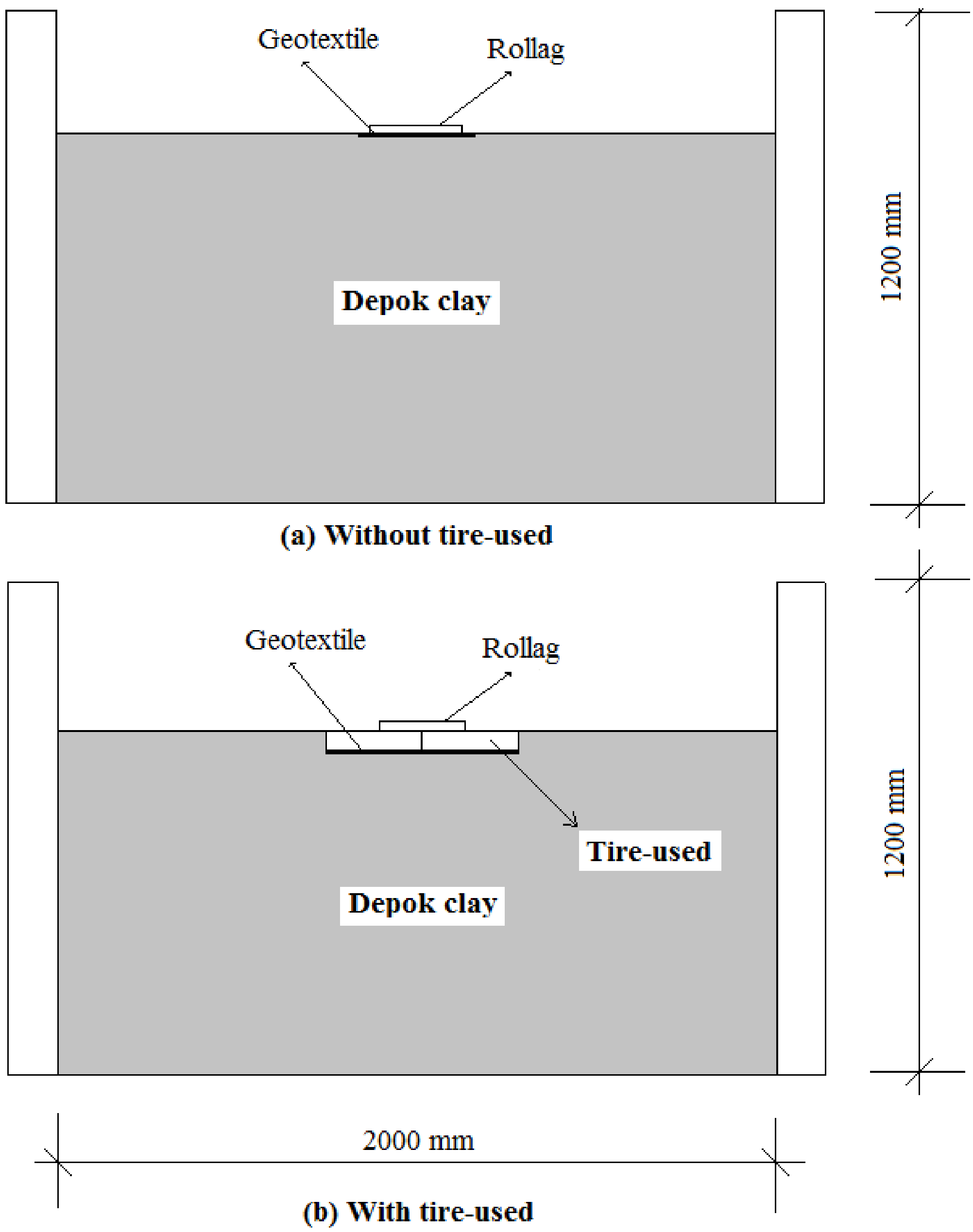


Fig. 3. Typical of laboratory experiment without and with tire-usedin one layer

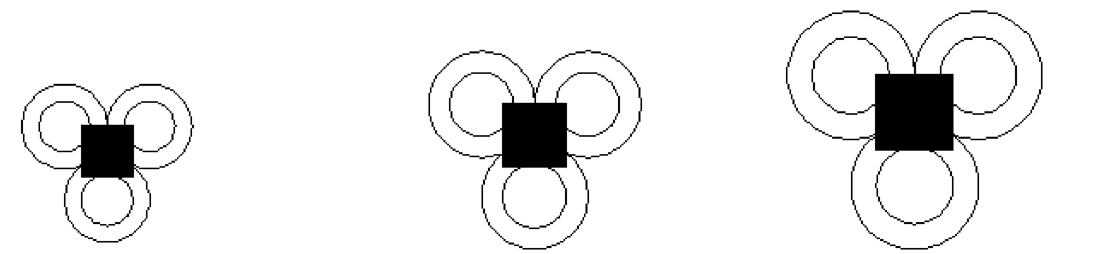
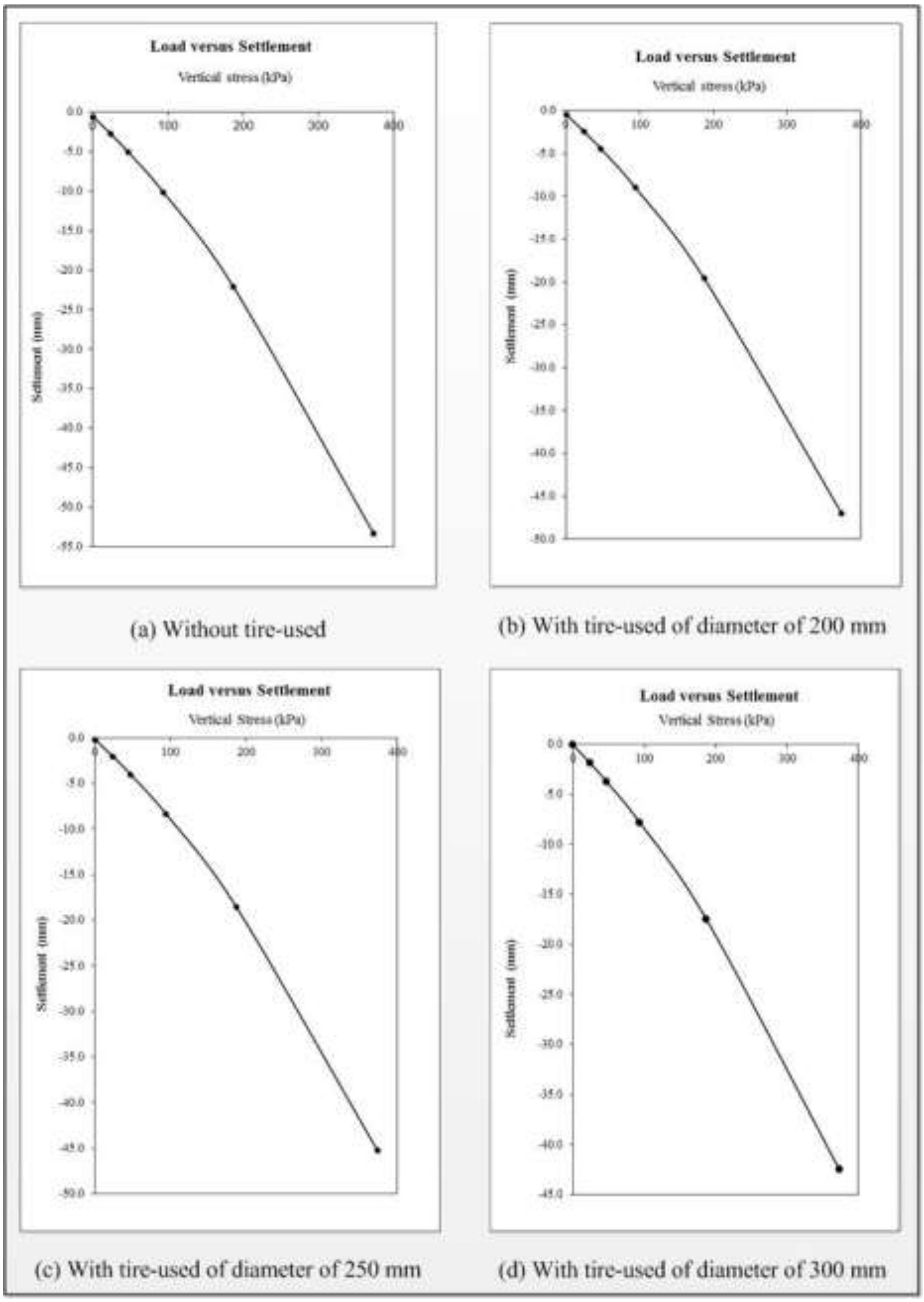


Fig. 4. Model configuration of tire-used and rollag

Table 2. Input parameters used for execution the PLAXIS Program

Depok Clay		Rollag		Tire-used	
γ_{dry}	11.7 kN/m^3	γ_{dry}	24 kN/m^3	γ_{dry}	15.81 kN/m^3
γ_{wet}	19.0 kN/m^3	E	2.10^5 kN/m^2	γ_{wet}	19 kN/m^3
E	300 kN/m^2	μ	0.25	E	1.67.10^5 kN/m^2
μ	0.45	ϕ	0^o	μ	0.3
ϕ	0^o	c	0 kN/m^2	ϕ	34^o
c	39 kN/m^2	ψ	0^o	c	20.8 kN/m^2
ψ	0^o			ψ	4^o



(a) Without tire-used

(b) With tire-used of diameter of 200 mm

(c) With tire-used of diameter of 250 mm

(d) With tire-used of diameter of 300 mm

Fig. 5. Loads versus settlement for all models

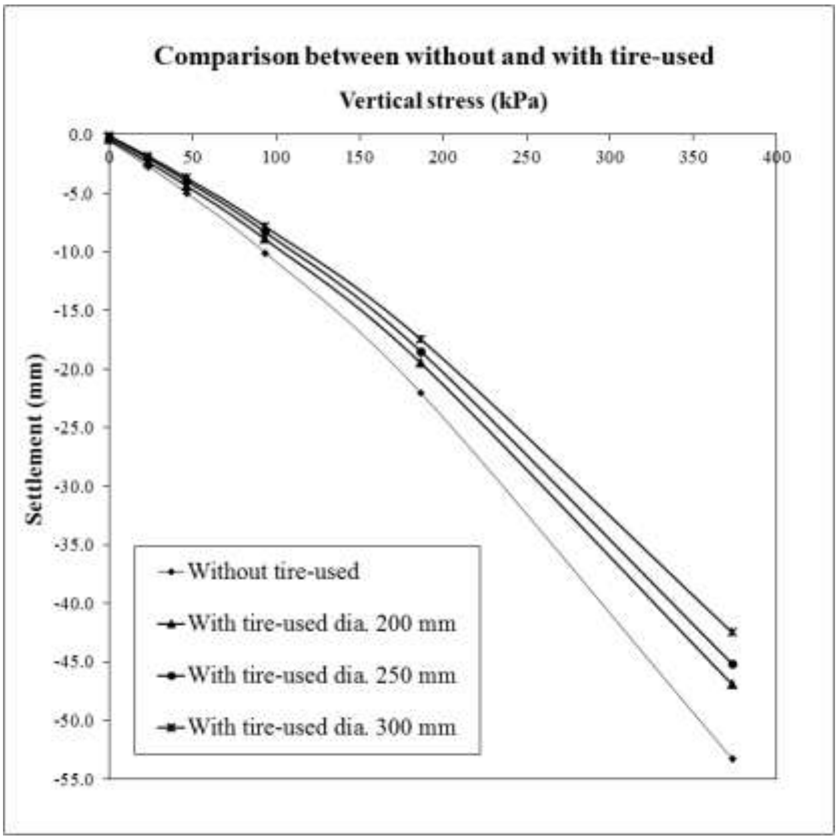


Fig. 6. All experimental results without and with tire-used

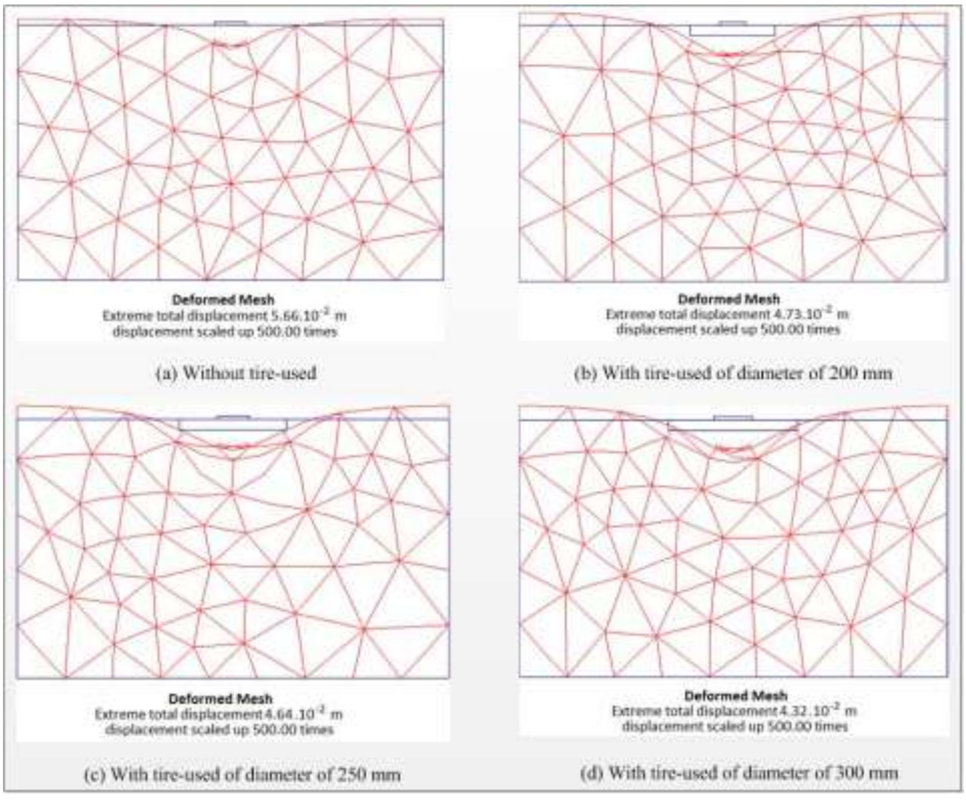


Fig. 7. Soil collapse model for foundation model (rollag) wihout and with tire-used