The change of value of soaked-CBR in embankment of subgrade due to water logging and repeated vehicles load

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Abstract. The value of soaked-CBR in subgrade soil is very important in the highway pavement thickness design [1]. If the soaked-CBR value of the subgrade does not meet the requirements, it is necessary to improve the soil by blasting with a better material. This is done to prevent damage to the road. Damage to the pavement surface may also cause damage to the subgrade. Alternatively, the damage to the pavement surface begins with damage on the subgrade. If the subgrade decreases in its power - caused by repetitive vehicle loads, otherwise known as repetition of vehicle load, then it can collapse the foundation layer, in which - then continues on the surface damage. Based on the phenomenon, this research is conducted to know the change of soaked-CBR value on subgrade soil due to water logging and repetition of vehicle load passing. The result shows that the soaked-CBR value will increase along with the number of vehicles passing up to 25x passings, then down to 50x passings which is the lowest value of all load variations. After 50x passings, CBR value will increase slightly up to 250x passings which then decrease until the end of the research.

1. Introduction
The subgrade of highway is the base ground supporting the pavement construction design the road, where the CBR value in the subgrade has a large influence [1]. The CBR value used in pavement thickness design is the value of soaked-CBR. When the soaked-CBR value of the subgrade does not meet the requirements, it is necessary to treat the subgrade, using form of a better material or stabilization [2]. Treatment of subgrade with the better soil moisture is intended to increase the value of soaked-CBR, or to increase the capacity of the soil.

In highway pavement construction, repair subgrade is positioned under the foundation layer. When there is damage to the surface of the pavement continuously, it damages the foundation layer, then the subgrade is also damaged. Alternatively, the damage to the pavement surface is started by the damage on the subgrade.

While the subgrade decreases its strength caused by repetitive vehicle loads, otherwise known as vehicle load passing, it can collapse the foundation layer which then continues on the surface damage. Based on [3, 4] the damage that occurs in the subgrade is largely due to the water logging that cannot drain out, so that it continuously receives the repetition of the vehicle load, it will be easier to damage.
The condition of early damage to road pavement as mentioned above should not occur, if the traffic of passing vehicles and other factors is in accordance with the planning, because in the calculation of pavement construction planning, the CBR value for subgrade 1 using soaked CBR value. The CBR value represents the value of ground quality when compared to standard materials in the form of crushed stone having a 100% CBR value (AASHTO) [5], and the CBR value of soaking is the CBR value of soil in water-saturated condition whose collapse mechanism is due to the compressive load increases continuously in the function of time until the penetration decrease reaches 0.5". The load or compressive force which causes a decrease in penetration to 0.1” or 0.2” is compared to the standard load.

However, the example case in Pantura, East Java, Indonesia, there is still early damage especially if there is water logging continuously in the base and subbase layers. This condition was apparently answered by [6, 7] that unstable subgrade or soft subgrade conditions allow for settlement or deformation when subjected to repeated passing. Some images of road damage due to the presence of standing water are shown in figure 1.

![Figure 1. Example of road damage due to waterlogging.](image)

The damage caused by water that occurs almost in all lowland areas in Indonesia, it is important to know the influence of water puddle on the degradation of CBR value immersion. In addition, the effects of excessive load and heavy vehicle reps also need to be studied, given that the largest vehicles in Indonesia have excessive payloads. On the basis of this thinking, this research is conducted in order to know the influence of waterlogging, overload and heavy vehicle reps on the degradation of CBR.

From all the above descriptions, it is found a problem that needs to be searched for and then sought the solution, that is whether the combination of water pool and repetitive load within a certain period of time in the foundation layer and subgrade cause the change of CBR value.

2. Material and method

2.1. Material

In this study embankment is used material taken from the district of Malang, East Java, Indonesia. The test results of physical properties as shown in table 1.

| Parameter                  | Result value | Unit   |
|----------------------------|--------------|--------|
| Liquid Limit               | 56.88        | %      |
| Plastic Limit              | 30.98        | %      |
| Plasticity Index           | 25.89        | %      |
| Optimum Moisture Content   | 25.36        | %      |
| Max dry density            | 1.527        | gr/cc  |

Material with parameters as shown in table 1 is included in the MH classification. Preliminary CBR values before some treatments have ranged from 6% to 10%, so the material is qualified to be used as an embankment material.
2.2. Method
The method used in this study is a modified soaked-CBR testing method. The modifications made in this study were to use cyclic loading prior to CBR testing. The purpose of this cyclic loading is to know the number of vehicle passing that weigh on the soil. Other modifications to the CBR test are also performed during the testing process by providing a water logging as well as – it is the initial purpose of the research, is to determine the effect of water logging on the value of soaked-CBR.

With the presence of water logging during the testing CBR in the laboratory, it will have the same value as well as in the field when there is a damage by the stagnant water. In order to prepare the specimens until immersion test uses the applicable rules, namely by giving energy compacting as much as 56x blows per layer. The number of layers in each specimen is 5 layers. Then soaked for 4 days. The tool used for testing is also the same tool as per the common applicable rules.

3. Result and discussion
This research is conducted to know the change of soaked-CBR value on subgrade-soil caused by water logging and vehicle repetition passing. In the process of conducting the research, there are variations vehicle and their passing. Variation of vehicle load is intended to know the value of soaked-CBR when the soil burdened with several variations, namely 50, 100 and 150 Psi. While the variation of the number of passing as the result is shown in table 2. The variation in the amount of load is based on the pressure of the wheels of the light vehicle, which is assumed to be 50 Psi, the wheel pressure of the normal vehicle is 100 Psi, and the wheel pressure of the heavy vehicle is 150 Psi.

Part of the process of conducting the research is shown in figure 2. In figure 2 (a) it shows the condition of the specimen after loading and seen there are parts deformed. This proves the visual condition in the field that if the soil with the parameters as used in the study, subjected to repeated loading will experience a deformation. In figure 2 (b), shows the surface smoothing process of the specimen before CBR testing. And figure 2 (c) shows the CBR testing process.

From table 2 and figure 3, it can be seen that the three CBR test curves have a trend not very different at all vehicle wheel pressure, but have a change in the CBR value on each test of the number of vehicle paths. From the test results, for the three variations of wheel pressure, the change in CBR value increased on 10x the number of trajectories, then decreased greatly on 50x the number of trajectories. The largest decrease amount, up to 45% for wheel pressure 150 Psi. As for the pressure of 50 and 100 Psi wheels respectively by 20% and 30%. The CBR value at 50x the number of passes is the lowest CBR value in all wheel pressure variations. Furthermore, on the variation in the number of passes after 50x to 250x, the CBR value changes slightly and will change downward in the number of passes from 250x to 300x. Given the changing value of CBR, it is possible that this problem is one cause of premature damage to road pavement.

Table 2. Value of CBR (%) vs. Number of passing (n) and pressure variations (P) from soil.

| n    | P = 50 Psi; | P = 100 Psi; | P = 150 Psi; |
|------|-------------|--------------|--------------|
| 0    | 5.20        | 9.32         | 8.00         |
| 10   | 7.62        | 9.91         | 16.33        |
| 25   | 5.50        | 8.65         | 14.44        |
| 50   | 4.50        | 4.75         | 7.49         |
| 70   | 7.49        | 8.66         | 10.00        |
| 100  | 10.07       | 9.32         | 11.99        |
| 150  | 11.15       | 10.16        | 12.82        |
| 250  | 14.00       | 11.70        | 15.00        |
| 300  | 12.74       | 9.91         | 14.44        |
Figure 2. Test specimens in the testing process.

Figure 3. The soaked-CBR value relationship curve and the number of vehicle passing on the soil.

The change in immersion CBR value in this study has a difference with the change of CBR immersion value in the research that [8] and [9] have done. The difference in research being conducted with previous research lies in the modified methodology of CBR testing and its loading system. So the very important value obtained from this study is to know the change of CBR value when loaded with some variation of wheel pressure which can be interpreted that this research can be applied on the road with various classes according to the allowable wheel pressure limit. Another important result is that CBR values on the ground can be changed after being repeated by any vehicle. So it is very important to know by the planners and implementers of road pavement construction, especially the flexible road pavement, to be able to pay attention to the implementation starting from hoarding for subgrade treatment to foundation coating so as to maintain the CBR plan value until the end of the road plan. It is advisable to avoid the occurrence of early damage to road pavement.

4. Conclusion
Based on the research, it can be concluded that the water logging and repetition of vehicle load can cause changes in the value of soaked-CBR. This has been proven by the results of research which states that for the three variations of wheel pressure, the change in CBR value increased on 10x the number of paths, then decreased greatly on 50x the number of trajectories. The largest decrease amount, up to 45% for wheel pressure 150 Psi. As for the pressure of 50 and 100 Psi wheels respectively by 20% and 30%. The CBR value at 50x the number of passes is the lowest CBR value in
all wheel pressure variations. Furthermore, on the variation in the number of passes after 50x to 250x, the CBR value changes slightly and will change downward in the number of passes from 250x to 300x. Given the changing value of CBR, it is possible that the problem of water puddles and vehicle load reps as one cause of premature damage to road pavement.

References
[1] AASHTO 2008 Standard Specifications for Transportation Materials and Methods of Sampling and Testing Part 2: Tests (Washington D.C: AASHTO)
[2] Tjie-Liong G 2006 Konsep Desain Geosynthetics Untuk Konstruksi Jalan (Geosynthetics Design Concept for Road Construction) Road Construction in Indonesia with Special Reference to the Role of Geosynthetics Indonesian Chapter of IGS
[3] Mochtar I B 1999 Penelitian dan Pemrosesan Data Teknik Jalan Bina Marga Jawa Timur Research Report
[4] Sugiyanto M A 2007 Penurunan kinerja lapis pondasi bawah karena kandungan fraksi halus berlebih hasil kontaminasi material tanah dasar menyebabkan terjadinya kerusakan perkerasan jalan
[5] Austin R A and Gilchrist A J T 1996 Enhanced performance of asphalt pavements using geocomposites Geotextiles and Geomembranes vol 14 pp 175-186
[6] Yasuhara K, Yamanouchi T 1983 Approximate Prediction of soil deformation under drained-repeated loading Soils and Foundations vol 23 no 2 pp 13-25
[7] Hu A F, Zhang X D and Jia Y S 2014 Research on the permanent settlement of saturated soft subsoil Advances in Soil Dynamics and Foundation Engineering pp 168-177
[8] Etim R K, Eberemu A O and Osinubi K J 2017 Stabilization of black cotton soil with lime and iron ore tailings admixture Transportation Geotechnics vol 10 pp 85-95
[9] Kumar D, Nigam S, Nangia A and Tiwari S 2015 California Bearing Ratio Variations in Soil Reinforced with Natural Fibres (A Case Study Bhopal Bypass Road) International Journal on Emerging Technologies vol 6 no 2 pp 95-104