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Analyzes of Rubber Bedded, Lateral Loaded Single Pile by Plaxis 2D

Ercan Egemen Basar
Civil Engineering Department, Suleyman Demirel University, Isparta, Turkey
Orcid Number: 0000-0001-8175-6923

ABSTRACT: In this study, lateral loaded single pile either with rubber bedded were analyzed in cohesionless soil. By rubber bedding how differated the moment values and pile length, head diameter ratio. For this purpose 3 different pile diameter such as 0,40m., 0,60m.,0,80m. 2 different volume rubber bedding and every combination was analyzed with two L/D values. In total 18 plaxis 2D analyzes exist in the study. Lateral loaded single pile interacts with soil either different with rubber bedded one and soil structure interface has been important parameter. Rubber bedding reduces moment values throught the pile length.This reducing factor allows the designer more economical and secured values. On the other hand pile's different L/D ratios gives varying values on moment either in rubber bedded either in dense sand. By foreseeing this design parameter is important for more economical and efficient designing.

KEYWORDS: Lateral Loaded Pile, Rubber bedding, Plaxis 2D

1. INTRODUCTİON

In the literature there are so many theoretical methods for the Solution of the lateral loaded piles. Those are Broms, Brinch-Hansen, p-y e.t.c. those methods are usually in the principle of force-soil-pile interaction. However those therotical based methods are lack of some paremeters in case of soil-pile interaction. At this point finite element methods cover the lacking situation of those theoretical based methods because of the nonlinear behaviour of pile soil interaction. Lateral loaded piles are frequantly implemented in site conditions such offshore platforms, wind, eccentricity, earthquake e.t.c. Designing of laterally loaded pile is considered for the biggest load combination. In this case design moment or shear force can reduced by cushioning the pile in friction area. In this study Plaxis 2D finite element programme is utilisied for the analyses of the laterally loaded rubber cushioned in cohesionless soil. Between the pile and soil rubber cushioed as interface. As result of cushioning pile is not directly in contact with dense soil. In the results cushioning is reducing the maximum moment and maximum shear forces. This effecting the design of the laterally loaded pile. In principle laterally loaded pile designing problem is soil-sttucture interaction problem. Main factors for this design is pile-soil interface interaction[11]. Cushioning is effecting the displacement values of the laterally loaded piles. However in the case of high values of the force on charge to the laterally loaded pile and soil together withstanding. In other words interfacing elemnts between the pile and soil distincts the designing moment, shear or displacement values of the lateral design[1]. In this study as the result of the lateral loaded pile in cohesionless dense soil is investigated such in the condition of rubber cushioning between the soil-pile interface, this cushioning is reducing the maximum moment, shear, displacement values of the pile[11]. And this reducing effection is considered in main design parameters of the pile L/D ratio.

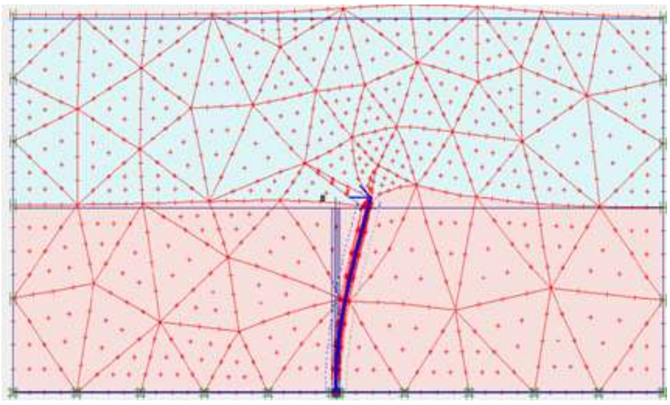

Figure 1. Image of a laterally loaded pile in Plaxis 2D

2. LİTERATURE REVİEW

Sawwaf[4] studied experimental in different material properties of laterally loaded piles in different sand density in combination of geogrids. In this study gogrids gave positive impact for laterally loaded piles. In this impact geogrid’s pulling behaviour is dominating. However relative denstiy of the cohesionless soil is resulting the displacement values of the pile. Uncuoğlu et al.[2] studied with Plaxis 3D and theoretically about the lateral loaded monopiles. In the study it is mentioned that finite element method and theoretical formulas are in harmony.

Abbas et al.[7] In their study, they modeled a 3-dimensional single pile with the finite element method and examined the effect of the geometric shape of the pile and the L/D ratio on the lateral load carrying capacity of the pile. Accordingly, they concluded that the load carrying capacity of square piles is better than round piles, and the pile head rotation values are lower at a certain L/D ratio. Terzi et al.[3] In their study, they examined the lateral loaded piles both theoretically and with the finite element method. Theoretically, they used the bed coefficient and p-y method and Sap2000 and Lpile programs as finite elements. Theoretically, they concluded that the p-y method gives more accurate results for laterally loaded piles. On the other hand, in these four different analyzes applied for the same pile model, it was determined that the laterally loaded piles were affected by the soil compaction at a very high level, that is, as a result of the increase in the compaction, the pile was highly affected by this increase, and it was determined that the piles were at safer numerical values in terms of displacement, shear force and moment parameters. This situation shows the importance of pile-soil interaction in the light of the analyzes made. Lassaad et al.[8] In their study, they analyzed the laterally loaded single pile Poisson ratio in different soils. Accordingly, as the Poisson ratio increased, the lateral load carrying capacity of the pile increased. In their study, Abnavi and Zomorodian[6] examined how polymer wastes affect the behavior of laterally loaded piles in cohesionless soils and how they improved the final bearing capacity of laterally loaded piles with model tests. Accordingly, they concluded that up to a certain amount by weight, polymer wastes contribute to the lateral resistance of the piles, but after a certain amount this contribution is less or even absent. On the other hand, they concluded that the pile gives very good lateral resistance with the addition of polymer in the case where the soil density increases, where the lateral loaded piles are most affected by the soil firmness. Uncuoğlu and Laman[5] examined the lateral loaded piles with the non-linear finite element program Plaxis 3D in their studies. Accordingly, they concluded that the most dominant factor in the final bearing capacity of the lateral loaded piles is the soil density, that is, the interaction of the soil with the pile affects this situation the most. In their study, Laman and Uncuğlu[1] subjected the pile to lateral load on loose and compact sand ground and examined the changes in the model tests. Among the parameters that changed in the study are the cross section of the pile, the material of the pile, the pile head pile length ratio. As a result, it is shown that the pile has an optimum pile head pile length ratio as a design parameter and the soil density affects the lateral load carrying capacity of the pile at very high values, even up to 5 times, when the pile is exposed to lateral load. In terms of this study, it indicates that a material that can contribute positively to the interaction of the pile with the ground can provide a significant benefit in the applied project. On the other hand, the main reason for this interaction comes from the material in the pile-soil interface. It is certain that the stiffness values to be applied to this interface will affect the cross-section effect values of a different material and some important pile design parameters.

3. MATERİAL AND METHOD

In this study, the behavior of laterally loaded single piles in cohesionless soil was investigated using the Plaxis 2D program. It is focused on how these parameters change this interaction by changing some parameters in the pile and soil interaction. Among these parameters are the pile length pile diameter ratio L/D Rubber bearing amount. In the analyzes made in the study, 3 different pile head diameters, 2 different pile lengths and 2 different rubber bedding volumes were used. There are 5 different L/D ratios in the analysis. A total of 18 analyzes were performed with plaxis 2D for this study.

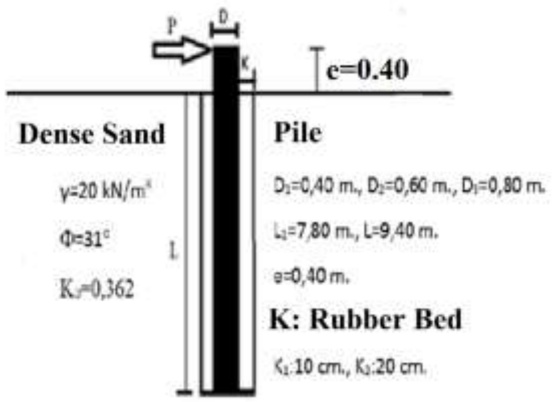

Fig 2. Schematic representation of the Plaxis model

3.1. Material

The parameters in Table 1 represent a dense sand. The analyzes made are only parameters that represent the firm sand ground and are defined to the program [11].

Table 1.Plaxis Input Soil Parameters

Soil Properties		
Parameter	Value	Unit
γ	20	kN/m^3
Φ	31	-
E	13000	kN/m^2
G	5000	kN/m^2

Table 2. Plaxis Pile Input Parameters

Pile Properties		
Parameter	Value	Unit
E	30250	kN/m^2
D_1	0.40	m
D_2	0.60	m
D_3	0.80	m
P	100	kN

Table 2 shows the stiffness values of a pile with S420 class reinforcement in C25 concrete. These values were entered into the plaxis and analyzed [9].

3.2. Method

Plaxis is a program designed to analyze problems in geotechnical engineering using the finite element method. In this study, the interaction of the laterally loaded single pile with the soil with the Plaxis package program has been examined. It has been included in the study, considering that the rubber bedding to be applied on the cohesionless ground will contribute positively to this interaction. While modeling the problem with the Plaxis 2D program, the dimensions of 50 m horizontally and 100 m vertically were chosen to prevent the related problem from being affected by the boundary effect. The pile discussed in the problem is selected in the elastic material type and modeled as a cylinder with a solid section, and the Elasticity modulus is entered for the C25 class reinforced concrete material in the literature for this section [9]. During the analysis of the problem, the ground water was neglected and the analyzes were made so that the materials were completely dry. The nonlinear analysis method, which can give the closest results to the real soil behavior, was chosen in the program steps. For this study, 3 different diameter piles, 2 different lengths of pile lengths and 2 different volumes of rubber beddings were used. Accordingly, 18 different analyzes were made in the Plaxis 2D program and it was found how these parameters affected the analysis values.

Table 3. Rubber Input Parameters

Rubber Properties		
Parameter	Value	Unit
γ	11	kN/m^3
E	1000	kN/m^2
G	416	kN/m^2

Table 3 shows the rubber values entered in the plaxis package program [10]. These values are the values of rubber produced in plastic processing factories.

4. FİNDİNGS AND DİSCUSSİON

In this study, when the moment values formed along the pile as a result of the interaction of the laterally loaded pile with the rubberized and non-rubberized soil by using the plaxis 2D program, the moment values along the pile were compared with each other, and a decrease in the moment values was determined in the rubber pile analyzes compared to the opposite situation. It has been determined that the change in the values is affected by the L/D aspect ratio and the rubber bearing volume.

4.1. Moment Values Through the Pile Depth

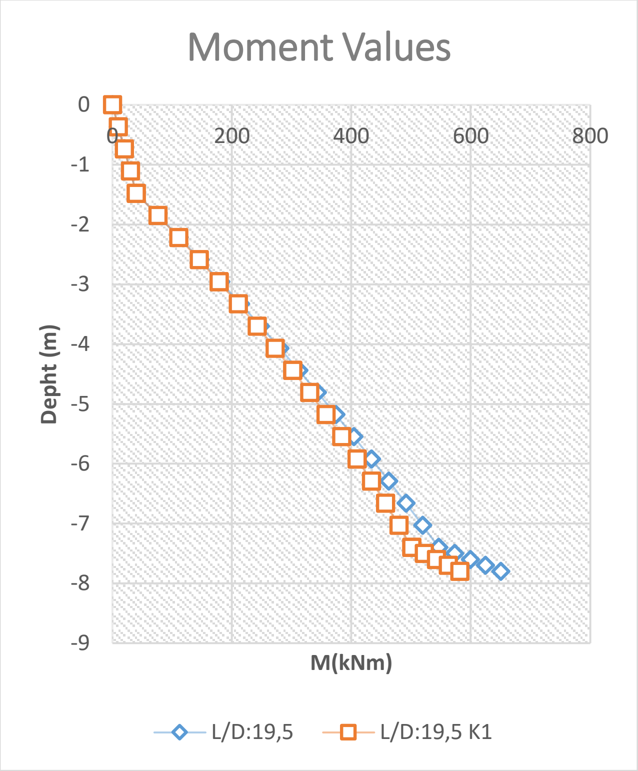

Figure 3. Non-rubber case and reverse case moment values

In Figure 3, moment values extending along the pile can be seen when D: 0.40 m. The rubberized condition caused a decrease in the moment values along the pile.

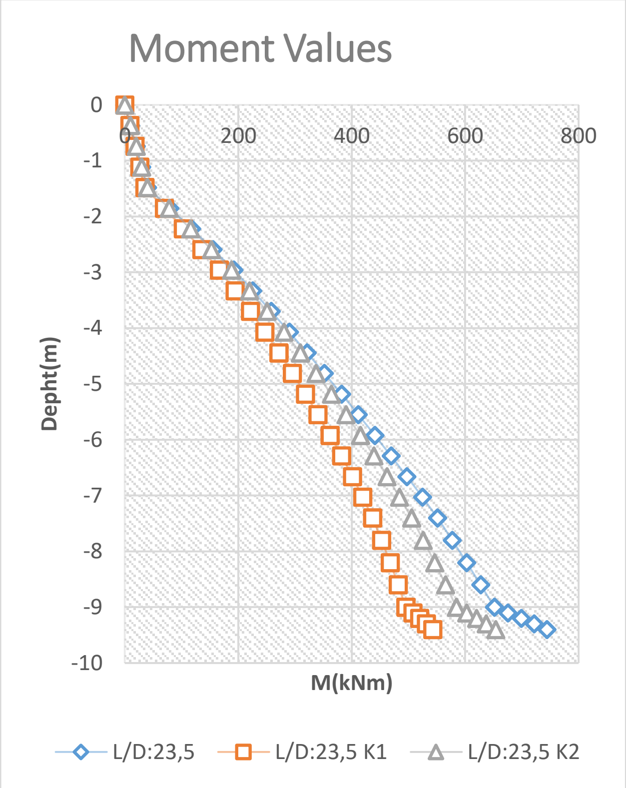

Figure 4. Non-rubber case and reverse case moment values

In Figure 4, moment values extending along the pile can be seen when D: 0.60 m. K2 rubber caused less decrease in moment values compared to K1. This indicates that an optimum rubber bearing volume should be applied. Because leaving too much soft material on the soil and pile interface can have an adverse effect on the pile impact values. Abnavi and Zomorodian[6] found that excess polymer additives had a negative effect.

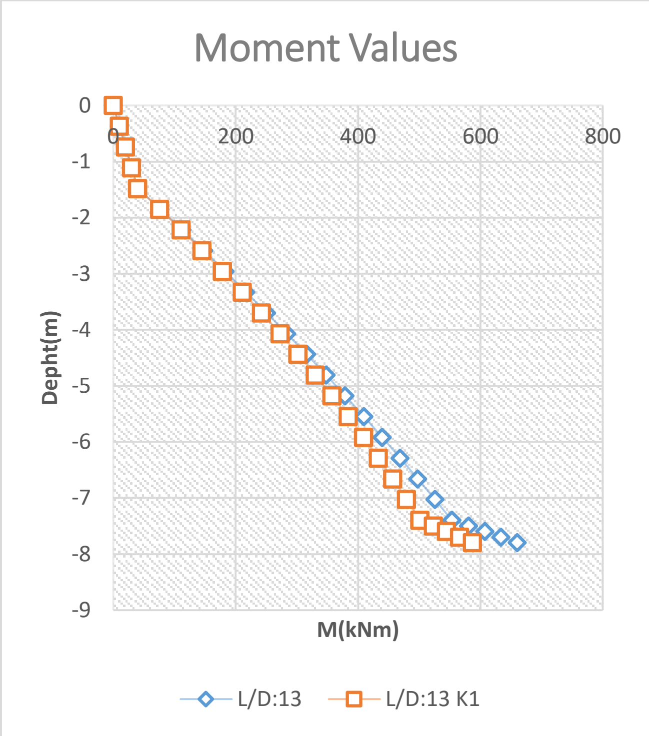

Figure 5. Non-rubber case and reverse case moment values

In Figure 5, moment values extending along the pile can be seen when D:0,80 m. In the case of socketing the pile tip, the socketing effect starts towards the deep and the graph slope changes here. The rubber bedding makes this more rigid region less fragile in terms of cross-sectional effects values by making the pile receive less moment at these transition depths.

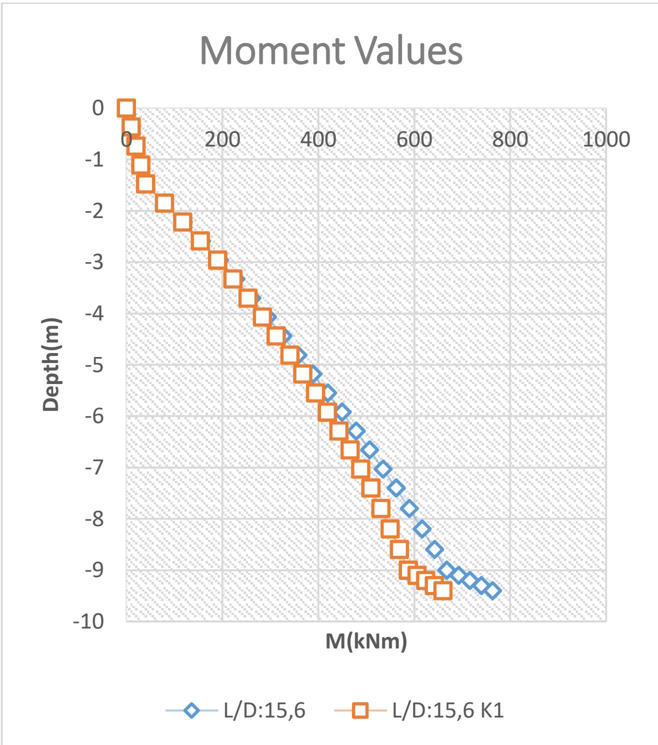

Figure 6. Non-rubber case and reverse case moment values

In Figure 6, moment values extending along the pile can be seen when D: 0.40 m. Thanks to the rubber bedding, a material with a higher Poisson ratio comes into contact with the ground at the ground pile interface, which causes a decrease in the moment values that occur under the same load [8].

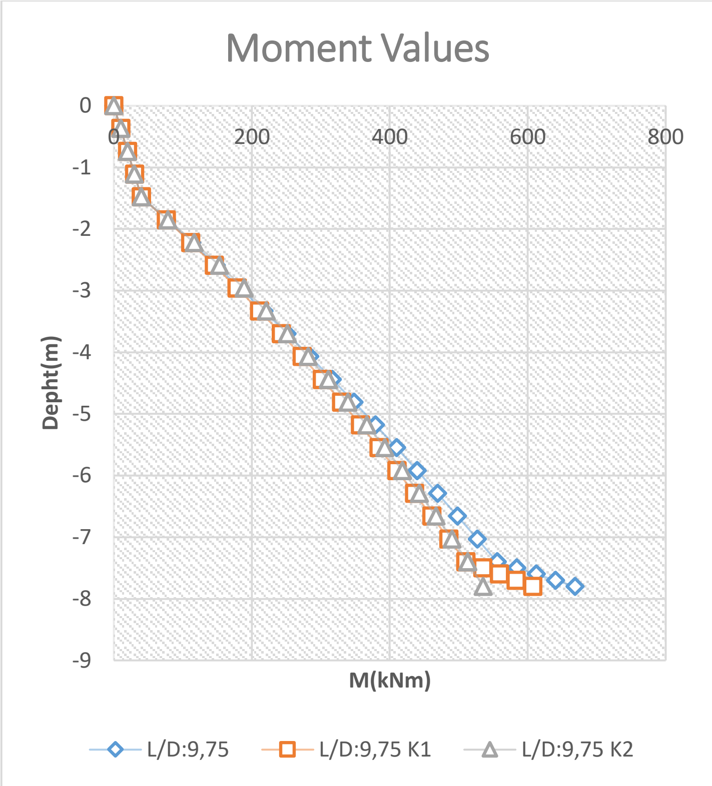

Figure 7. Non-rubber case and reverse case moment values

Similar to Figure 4, although the amount of rubber bearing K2 is higher than that of K1, it does not have as much effect as K1 on the reduction of moment values. The amount of rubber bedding should be kept at an optimum value[6].

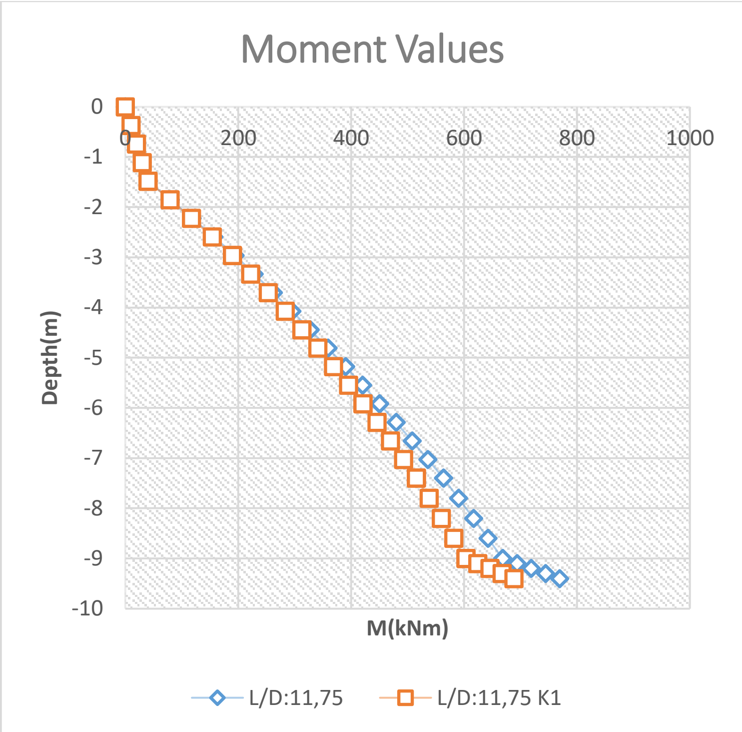

Figure 8. Non-rubber case and reverse case moment values

Figure 8 shows the moment values extending along the pile when D:0,80 m.

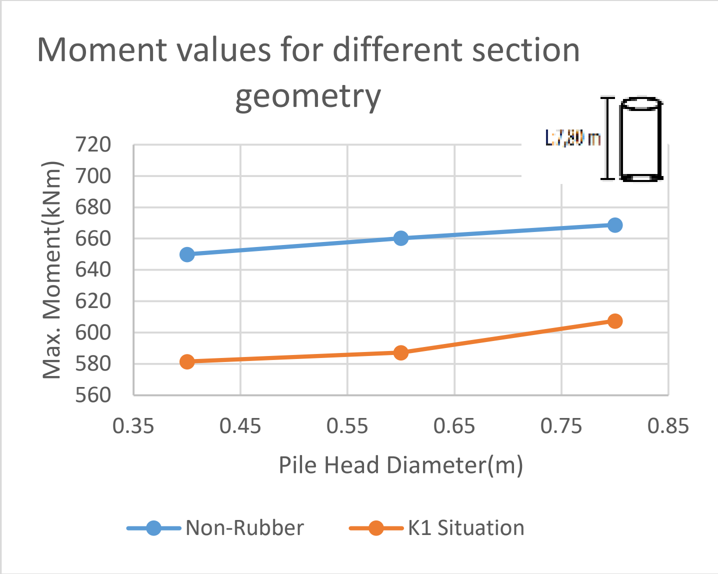

Figure 9. Changing According to Pile Head Diameter Max. Moment Values

As can be seen in Figure 9, as the diameter of the pile head increases, the maximum moment values on the pile also increase. The pile-soil interaction is directly affected by the cross-section dimensions.

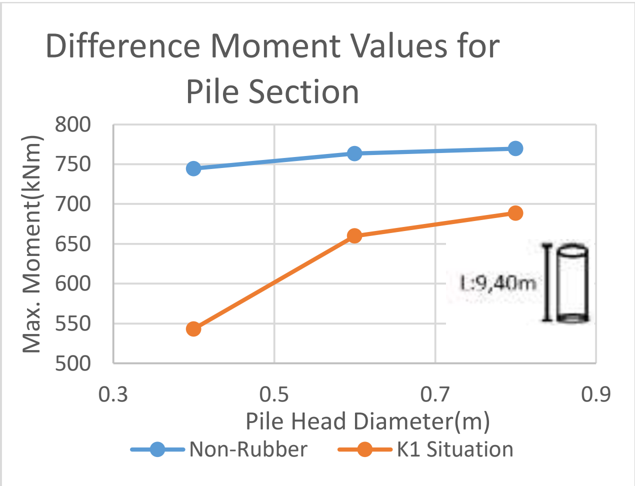

Figure 10. Changing According to Pile Head Diameter Max. Moment Values

As seen in Figure 10, the rubber bearing effect is greater in cases where the pile diameter is small. As the pile head diameter increases, the rubber bedding effect decreases.

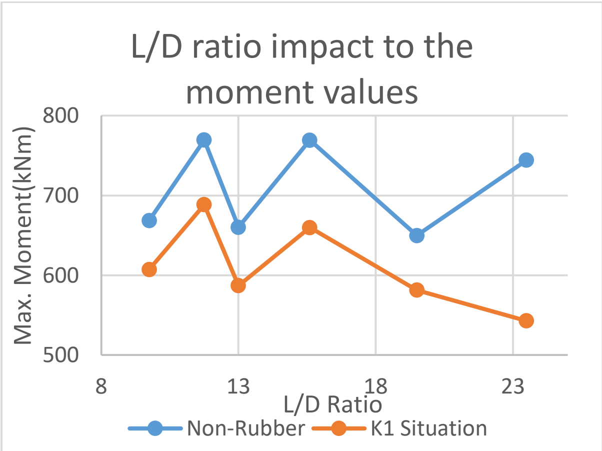

Figure 11. L/D ratio Max. Effect on Moment Values

As can be seen in Figure 11, the maximum moment values change with the change of the pile length and pile diameter ratio. By making changes in these dimensions, the cross-section effect values can be brought to the desired values within a certain limit. Keeping the maximum moment values and section dimensions parameters in balance is important for an economical and efficient project.

5. RESULTS

In this study, the moment values of the laterally loaded pile in cohesionless soil and the behavior of the pile in this soil were investigated. For this purpose, the L/D ratio, which is one of the most important parameters used in the design of the piles, and how it changes the maximum moment values that will occur at the depth of the pile when rubber bedding is made at the interface between the pile and the ground has been investigated.

Table 4. Reduced moments with rubber bearing(K1)

Pile Diameter	MAX. Mom. Ratio	Reducing Percent (%)
D=0.40	0,89	11
D=0.60	0,88	12
D=0.80	0,91	9

As can be seen in Table 4, the maximum moment values were compared with and without rubber. The rubberized case causes a decrease in the maximum moment values.

1. The rubber bedding thrown into the soil interface with the pile caused a decrease in the maximum moment values of the pile depth. However, increasing the volume of rubber bedding is inefficient after a point. In other words, the rubber bedding volume has an optimum value.
2. The behavior of lateral loaded piles has a complex nonlinear structure. Socketing the tip of the pile completely changes the pile behavior compared to the non-socketing situation.
3. The pile-soil interface is an important factor affecting the behavior. The rubber material placed at this interface can help reduce the cross-sectional effect values. For this purpose, a more economical and efficient design can be obtained as a result of this interface.
4. In dense sand, as the diameter of the pile head increases, the maximum moment value of the pile increases. Although the sand is the same in this interaction, the maximum moment value changes due to the growth of the pile section. This situation is directly related to the pile-soil interaction.
5. In this study, analyzes were made against the constant load that comes with 6 different L/D ratios. The increase or decrease of this ratio causes serious differences in socketed piles. This ratio is one of the main design parameters of lateral loaded piles. While the piles are being designed, the cross-sectional effect values that will come to the pile can be kept at the desired level with the help of this ratio and rubber bedding, and accordingly the design economy and safety can be ensured.
6. In the case of socketing the end of the pile in lateral loaded piles, a socketing effect is observed in the section towards the bottom of the pile due to the effect of this socketing. At these depths, the pile takes more moment than the upper sections. At these depths, the cross section of the pile remains more unsafe. However, rubber bearing reduces these values and provides a smoother transition to the socketing point of the pile.
7. In the analyzes with the largest diameter of the pile, the damping of the section effects was less than the piles with the smaller diameter. In other words, if the pile diameter is small, the pile soil system can be affected by bedding more easily.

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